# The NASA Glenn Research Center's Acceleration Measurement and Analysis Projects Support for the International Space Station (ISS)

## SAMS Support of ISS

***SAMS Team***

Kevin McPherson
Jennifer Keller
Eric Kelly
Ken Hrovat
Marcus Dejmek *(honorary member)*
Valentine Peretroukhine *(honorary member)*

# Outline

1. Science support/customers
2. Microgravity community feedback model
3. Timeline of acceleration system deployment
4. Location of acceleration sensor deployment
5. Overview of ug environment and characterization
6. Characterize some specific events and disturbances
7. Impacts on microgravity science
8. Moving forward
9. The “best 4 hours” plot

| ACRONYM | Definition |
|---|---|
| **ATV** | Automated Transfer Vehicle |
| **CIR** | Combustion Integrated Rack |
| **FIR** | Fluids Integrated Rack |
| **GRC** | Glenn Research Center |
| **HiRAP** | High Resolution Accelerometer Package |
| **MAMS** | Microgravity Acceleration Measurement System |
| **NASA** | National Aeronautics and Space Administration |
| **OARE** | Orbital Acceleration Research Experiment |
| **OSS** | OARE Sensor Subsystem |
| **PIMS** | Principal Investigator Microgravity Services |
| **RTS** | Remote Triaxial Sensor |
| **SAMS** | Space Acceleration Measurement System |
| **SE** | Sensor Enclosure |
| **TSH-ES** | Triaxial Sensor Head Ethernet Standalone |

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# Science Support/Customers

NASA's Physical Sciences Research Program conducts fundamental & applied research with experiments in various disciplines such as…

**Fluid Physics**

**Combustion Science**

**Materials Science**

**Fundamental Physics**

**Complex Fluids**

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**Combustion Science**

**Materials Science**

**Fundamental Physics**

**Complex Fluids**

**SAMS/MAMS** were designed to support these various science disciplines, and along with **PIMS** for analysis, these projects at **NASA GRC** also fill an ongoing role in support of…

**Vehicle Loads and Dynamics Monitoring**

**Technology Developers**

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**Technology Developers**

***collaboration***

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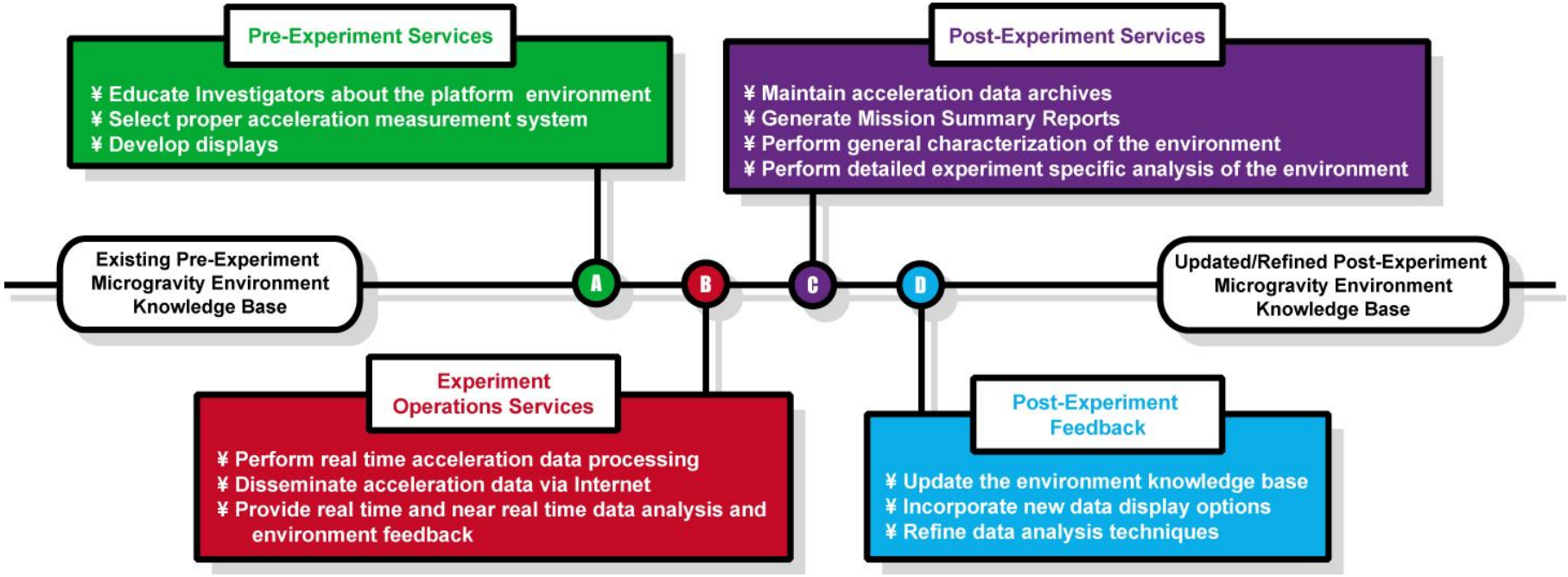
# Microgravity Community Feedback Model




**HIGHLIGHTS**

- **Real-Time Displays:** http://pims.grc.nasa.gov/html/PIMS_ISS_plots.html
- **Acceleration Data Archive:** http://pims.grc.nasa.gov/ftp/pad
- **Characterization Handbook:** http://pims.grc.nasa.gov/handbook
- Plans to Participate in **Open Government Initiative**

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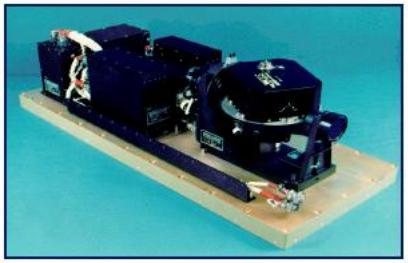
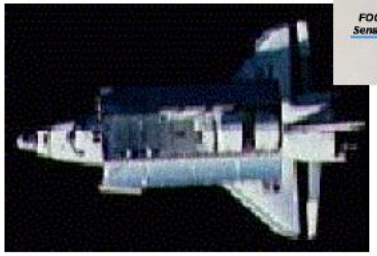
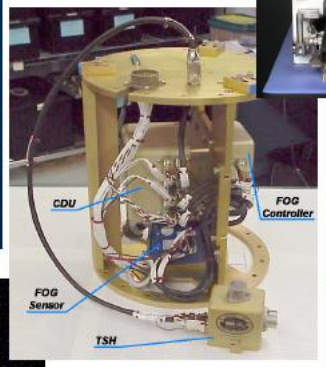
# Timeline of NASA GRC System Deployment











**SAMS TSH-ES (Compact Ethernet Standalone)**
**(0.01 to 400 Hz) Station Vibratory**

**SAMS RTS (Ethernet Distributed)**
**(0.01 to 400 Hz) Station Vibratory**

**MAMS HiRAP**
**(0.01 to 100 Hz) Station Vibratory**

**MAMS OSS**
**(DC to 1 Hz) Station Quasi-Steady**

**2028**

**RRS (0.1 arc/s)**
**1 sounding rocket, 1 shuttle**

**TSH-FF (0.01 to 200 Hz)**
**3 sounding rocket, 2 shuttle**

**OARE (DC to 1Hz) - 12 shuttle flights**

**7 SAMS Units (0.01 to 100 Hz)**
**21 Shuttle/MIR Flights**

SAMS Project Initiated

1986 1991 1994 1997 2000 2003 2006 2009 2012 2015 2018

YEAR

# Location of NASA GRC ISS Sensor Deployment

**Collectively, SAMS & MAMS Sensors Have Been Mounted in 21 Unique Locations**

| system | coord_name | location_name | r_orient | p_orient | y_orient | x_location | y_location | z_location |
|---|---|---|---|---|---|---|---|---|
| **MAMS** | **hirap** | **LAB1O2, ER1, Lockers 3,4** | **180** | **0** | **0** | **138.68** | **-16.18** | **142.35** |
| **MAMS** | **ossraw** | **LAB1O2, ER1, Lockers 3,4** | **90** | **0** | **0** | **135.28** | **-10.68** | **132.12** |
| **SAMS** | **121f02** | **LAB1S2, MSG, Upper Left Seat Track** | **0** | **0** | **90** | **161.95** | **40.39** | **157.64** |
| **SAMS** | **121f03** | **LAB1O1, ER2, Lower Z Panel** | **0** | **30** | **-90** | **191.54** | **-40.54** | **135.25** |
| **SAMS** | **121f04** | **LAB1O2, ER1, Lower Z Panel** | **0** | **30** | **-90** | **149.54** | **-40.54** | **135.25** |
| **SAMS** | **121f05** | **JPM1F5, ER4, Drawer 2** | **-90** | **-90** | **0** | **466.8** | **-292.06** | **214.58** |
| **SAMS** | **121f08** | **COL1A1, ER3, Seat Track near D1** | **0** | **0** | **180** | **371.17** | **193.43** | **165.75** |
| **SAMS** | **es05** | **LAB1S3, CIR, Front Panel** | **180** | **0** | **90** | **116.81** | **40.39** | **192.76** |
| **SAMS** | **es06** | **LAB1S4, FIR,** | **0** | **180** | **0** | **69.31** | **40.39** | **196.41** |
| SAMS | es08 | COL1F2, MSG, Ceiling Plate Y1-C3 Y2-D3 | 0 | 90 | -90 | 475.71 | 235.22 | 160.27 |
| SAMS | 121f02 | LAB1P3, CEVIS, Frame | 0 | 0 | -90 | 118.45 | -38.36 | 170.57 |
| SAMS | 121f02 | LAB1O2, ER1, Drawer 1 | -90 | 0 | -90 | 128.73 | -23.53 | 144.15 |
| SAMS | 121f02 | JPM1F3, TCQ, Lower Panel | 180 | -45 | 0 | 455.55 | -227.69 | 229.07 |
| SAMS | 121f02 | COL1D3, Forward Foot of FWED | 90 | -45 | -90 | 395.08 | 287.99 | 232.22 |
| SAMS | 121f05 | LAB1O1, ER2, Upper Z Panel | 90 | 0 | 90 | 185.17 | 38.55 | 149.93 |
| SAMS | 121f08 | LAB1S3, MSG, Ceiling Plate A2-A3 | -90 | 90 | 0 | 115.21 | 53.41 | 160.98 |
| SAMS | 121f08 | LAB1S3, MSG, Ceiling Plate D3-D2 | 90 | 90 | 0 | 87.99 | 55.19 | 160.98 |
| SAMS | 121f08 | COL1A1, ER3, B2 Panel | 0 | 180 | 0 | 374.17 | 166.19 | 157.03 |
| SAMS | 121f08 | COL1O1, FSL, ODM Seat Track | 0 | 90 | 0 | 434.37 | 183.25 | 147.01 |
| SAMS | 121f08 | COL1D3, Seat Track near A3 | 0 | -90 | 0 | 378.11 | 246.46 | 234.96 |
| SAMS | es08 | COL1F2, MSG, Ceiling Plage Y1-B1 Y2-A1 | 0 | 90 | 90 | 475.63 | 204.91 | 159.95 |

# Location of NASA GRC ISS Sensor Deployment

**Collectively, SAMS & MAMS Sensors Have Been Mounted in 21 Unique Locations**

Current

| system | coord_name | location_name | r_orient | p_orient | y_orient | x_location | y_location | z_location |
|---|---|---|---|---|---|---|---|---|
| MAMS | hirap | LAB1O2, ER1, Lockers 3,4 | 180 | 0 | 0 | 138.68 | -16.18 | 142.35 |
| MAMS | ossraw | LAB1O2, ER1, Lockers 3,4 | 90 | 0 | 0 | 135.28 | -10.68 | 132.12 |
| SAMS | 121f02 | LAB1S2, MSG, Upper Left Seat Track | 0 | 0 | 90 | 161.95 | 40.39 | 157.64 |
| SAMS | 121f03 | LAB1O1, ER2, Lower Z Panel | 0 | 30 | -90 | 191.54 | -40.54 | 135.25 |
| SAMS | 121f04 | LAB1O2, ER1, Lower Z Panel | 0 | 30 | -90 | 149.54 | -40.54 | 135.25 |
| SAMS | 121f05 | JPM1F5, ER4, Drawer 2 | -90 | -90 | 0 | 466.8 | -292.06 | 214.58 |
| SAMS | 121f08 | COL1A1, ER3, Seat Track near D1 | 0 | 0 | 180 | 371.17 | 193.43 | 165.75 |
| SAMS | es05 | LAB1S3, CIR, Front Panel | 180 | 0 | 90 | 116.81 | 40.39 | 192.76 |
| SAMS | es06 | LAB1S4, FIR, | 0 | 180 | 0 | 69.31 | 40.39 | 196.41 |

Previous

| system | coord_name | location_name | r_orient | p_orient | y_orient | x_location | y_location | z_location |
|---|---|---|---|---|---|---|---|---|
| SAMS | es08 | COL1F2, MSG, Ceiling Plate Y1-C3 Y2-D3 | 0 | 90 | -90 | 475.71 | 235.22 | 160.27 |
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| SAMS | 121f08 | LAB1S3, MSG, Ceiling Plate A2-A3 | -90 | 90 | 0 | 115.21 | 53.41 | 160.98 |
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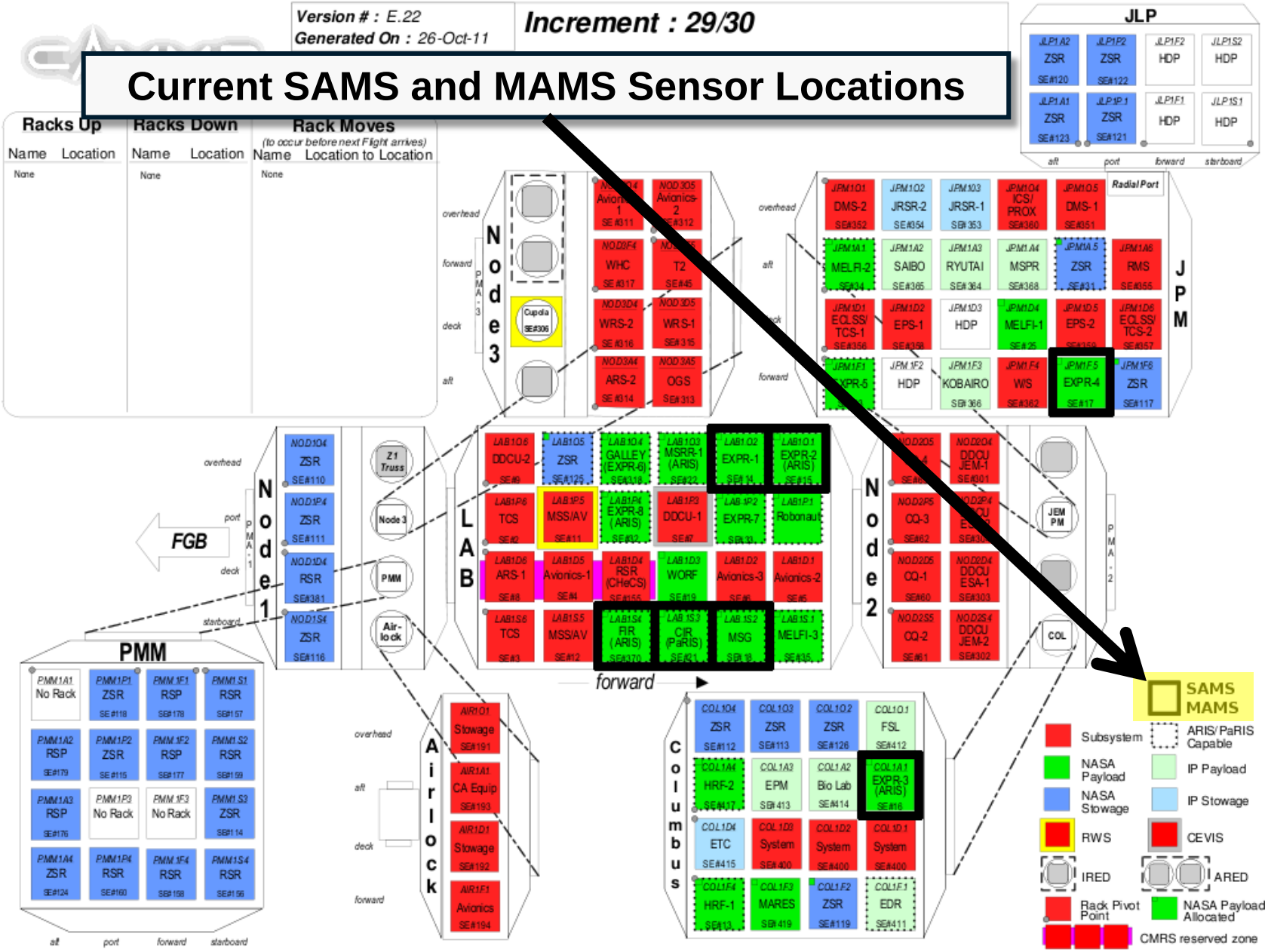
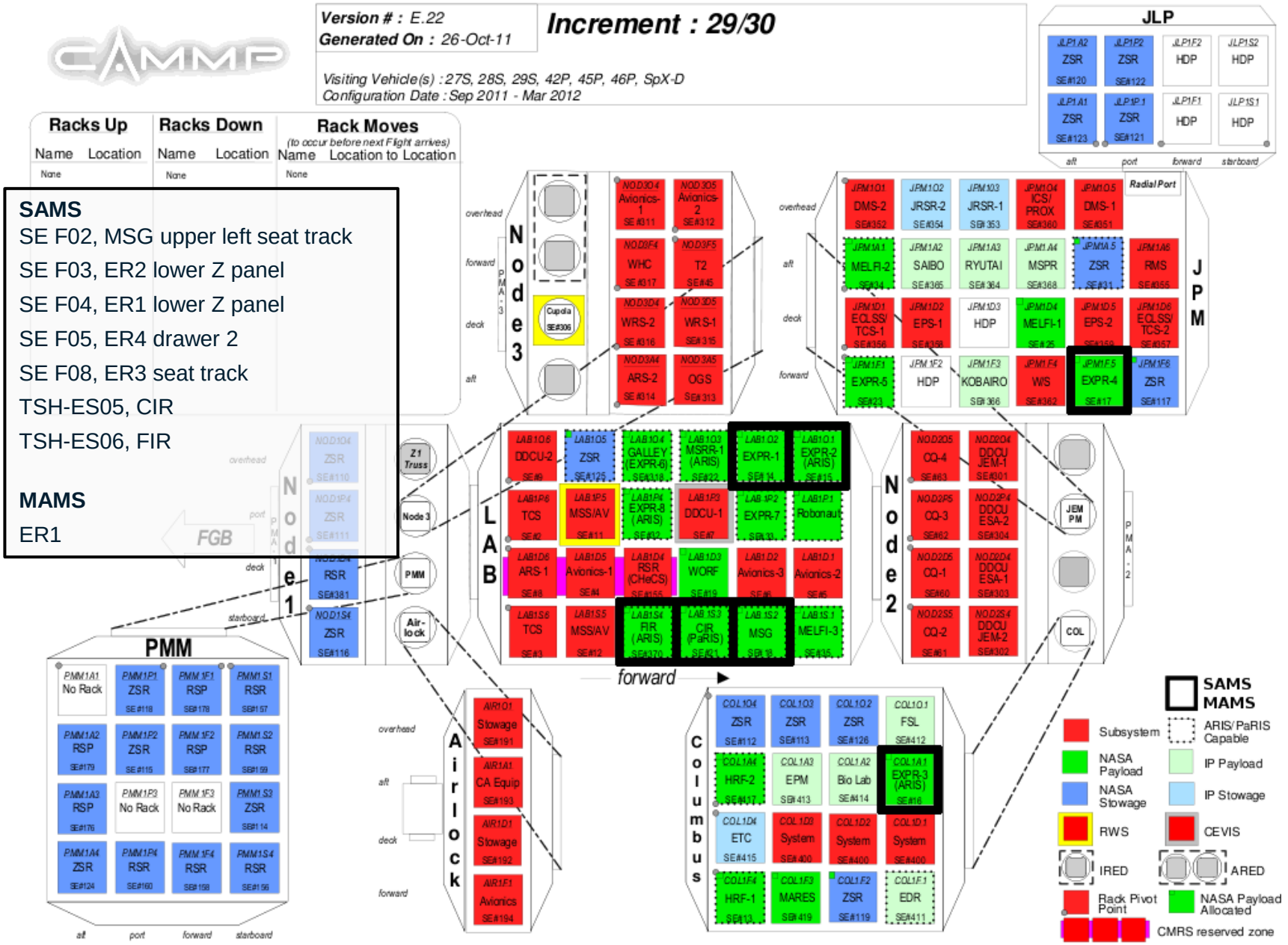
| SAMS | es08 | COL1F2, MSG, Ceiling Plage Y1-B1 Y2-A1 | 0 | 90 | 90 | 475.63 | 204.91 | 159.95 |

# Current SAMS and MAMS Sensor Locations

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Generated On : 26-Oct-11
Increment : 29/30
Visiting Vehicle(s) : 27S, 28S, 29S, 42P, 45P, 46P, SpX-D
Configuration Date : Sep 2011 - Mar 2012
Racks Up
Name Location
None
Racks Down
Name Location
None
Rack Moves
(to occur before next Flight arrives)
Name Location to Location
None
SAMS
SE F02, MSG upper left seat track
SE F03, ER2 lower Z panel
SE F04, ER1 lower Z panel
SE F05, ER4 drawer 2
SE F08, ER3 seat track
TSH-ES05, CIR
TSH-ES06, FIR
MAMS
ER1
JLP
JLP1A2 ZSR SE#120
JLP1P2 ZSR SE#122
JLP1F2 HDP
JLP1S2 HDP
JLP1A1 ZSR SE#123
JLP1P1 ZSR SE#121
JLP1F1 HDP
JLP1S1 HDP
aft port forward starboard
Node 3
NOD3O4 Avionics-1 SE#311
NOD3O5 Avionics-2 SE#312
NOD3F4 WHC SE#317
NOD3F5 T2 SE#45
Cupola SE#306
NOD3O4 WRS-2 SE#316
NOD3O5 WRS-1 SE#315
NOD3A4 ARS-2 SE#314
NOD3A5 OGS SE#313
JPM
JPM1O1 DMS-2 SE#352
JPM1O2 JRSR-2 SE#354
JPM1O3 JRSR-1 SE#353
JPM1O4 ICS/PROX SE#360
JPM1O5 DMS-1 SE#351
Radial Port
JPM1A1 MELFI-2 SE#304
JPM1A2 SAIBO SE#365
JPM1A3 RYUTAI SE#364
JPM1A4 MSPR SE#368
JPM1A5 ZSR SE#31
JPM1A6 RMS SE#355
JPM1D1 ECLSS/TCS-1 SE#356
JPM1D2 EPS-1 SE#358
JPM1D3 HDP
JPM1D4 MELFI-1 SE#25
JPM1D5 EPS-2 SE#359
JPM1D6 ECLSS/TCS-2 SE#357
JPM1F1 EXPR-5 SE#23
JPM1F2 HDP
JPM1F3 KOBAIRO SE#366
JPM1F4 WIS SE#362
JPM1F5 EXPR-4 SE#17
JPM1F6 ZSR SE#117
Node 1
NOD1O4 ZSR SE#110
NOD1P4 ZSR SE#111
NOD1P3 RSR SE#381
NOD1S4 ZSR SE#116
FGB
Z1 Truss
Node 3
PMM
Air-lock
LAB
LAB1O6 DDCU-2 SE#9
LAB1O5 ZSR SE#125
LAB1O4 GALLEY (EXPR-6) SE#318
LAB1O3 MSRR-1 (ARIS) SE#22
LAB1O2 EXPR-1 SE#14
LAB1O1 EXPR-2 (ARIS) SE#15
LAB1P6 TCS SE#2
LAB1P5 MSS/AV SE#11
LAB1P4 EXPR-8 (ARIS) SE#12
LAB1P3 DDCU-1 SE#7
LAB1P2 EXPR-7 SE#10
LAB1P1 Robonaut
LAB1D6 ARS-1 SE#8
LAB1D5 Avionics-1 SE#4
LAB1D4 RSR (CHeCS) SE#155
LAB1D3 WORF SE#19
LAB1D2 Avionics-3 SE#6
LAB1D1 Avionics-2 SE#5
LAB1S6 TCS SE#3
LAB1S5 MSS/AV SE#12
LAB1S4 FIR (ARIS) SE#370
LAB1S3 CIR (PaRIS) SE#21
LAB1S2 MSG SE#18
LAB1S1 MELFI-3 SE#435
Node 2
NOD2O5 CQ-4 SE#63
NOD2O4 DDCU JEM-1 SE#301
NOD2P5 CQ-3 SE#62
NOD2P4 DDCU ESA-2 SE#304
NOD2D5 CQ-1 SE#60
NOD2D4 DDCU ESA-1 SE#303
NOD2S5 CQ-2 SE#61
NOD2S4 DDCU JEM-2 SE#302
JEM PM
COL
forward
PMM
PMM1A1 No Rack
PMM1P1 ZSR SE#118
PMM1F1 RSP SE#178
PMM1S1 RSR SE#157
PMM1A2 RSP SE#179
PMM1P2 ZSR SE#115
PMM1F2 RSP SE#177
PMM1S2 RSR SE#159
PMM1A3 RSP SE#176
PMM1P3 No Rack
PMM1F3 No Rack
PMM1S3 ZSR SE#114
PMM1A4 ZSR SE#124
PMM1P4 RSR SE#160
PMM1F4 RSR SE#158
PMM1S4 RSR SE#156
aft port forward starboard
Airlock
AIR1O1 Stowage SE#191
AIR1A1 CA Equip SE#193
AIR1D1 Stowage SE#192
AIR1F1 Avionics SE#194
Columbus
COL1O4 ZSR SE#112
COL1O3 ZSR SE#113
COL1O2 ZSR SE#126
COL1O1 FSL SE#412
COL1A4 HRF-2 SE#417
COL1A3 EPM SE#413
COL1A2 Bio Lab SE#414
COL1A1 EXPR-3 (ARIS) SE#16
COL1D4 ETC SE#415
COL1D3 System SE#400
COL1D2 System SE#400
COL1D1 System SE#400
COL1F4 HRF-1 SE#13
COL1F3 MARES SE#419
COL1F2 ZSR SE#119
COL1F1 EDR SE#411
SAMS
MAMS
Subsystem
ARIS/PaRIS Capable
NASA Payload
IP Payload
NASA Stowage
IP Stowage
RWS
CEVIS
IRED
ARED
Rack Pivot Point
NASA Payload Allocated
CMRS reserved zone

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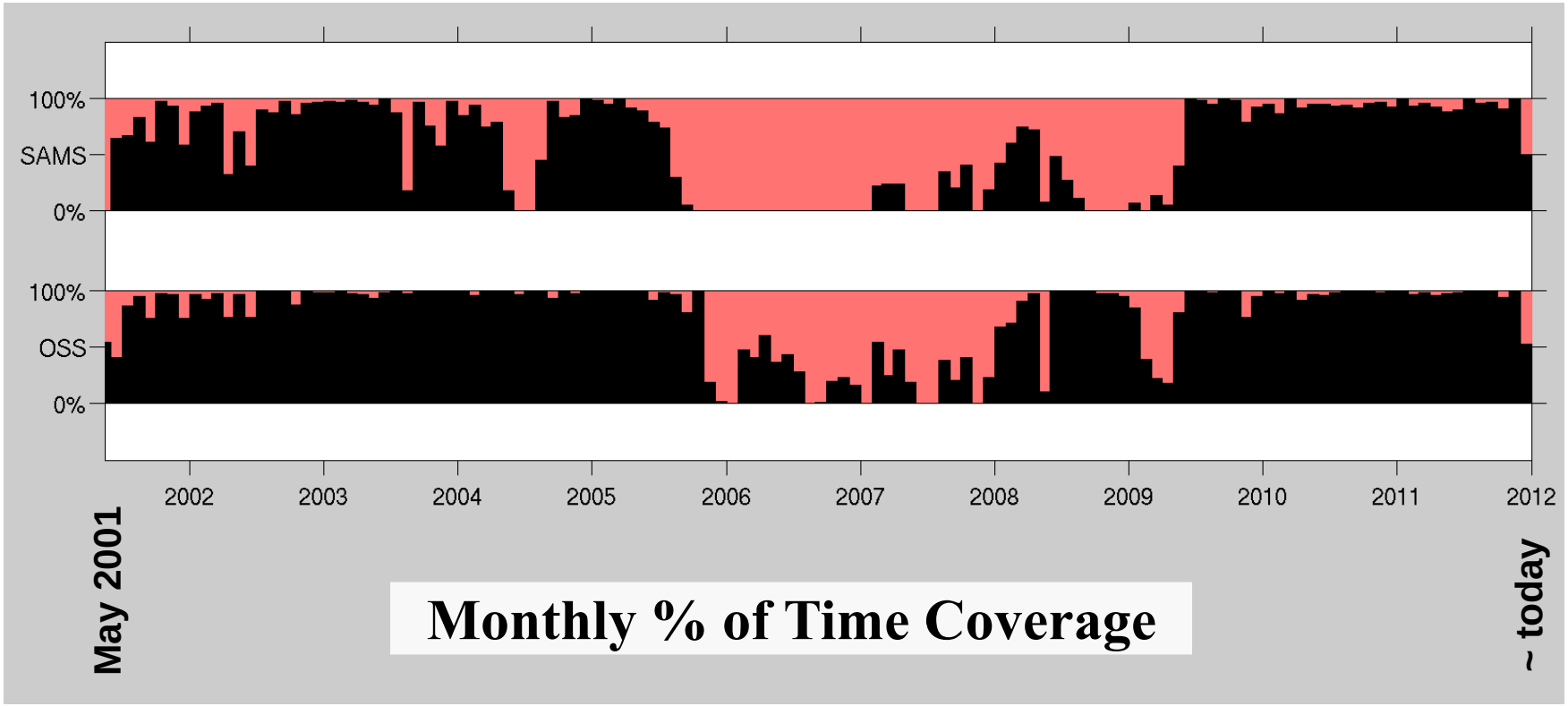
# How Much Acceleration Data?

**Approx. 95,000 actual hours** **over 197,000 sensor-hours**

***Since May of 2001 on the ISS, SAMS and MAMS have collected***

*over **179,283 sensor-hours***

*more than **7 terabytes***



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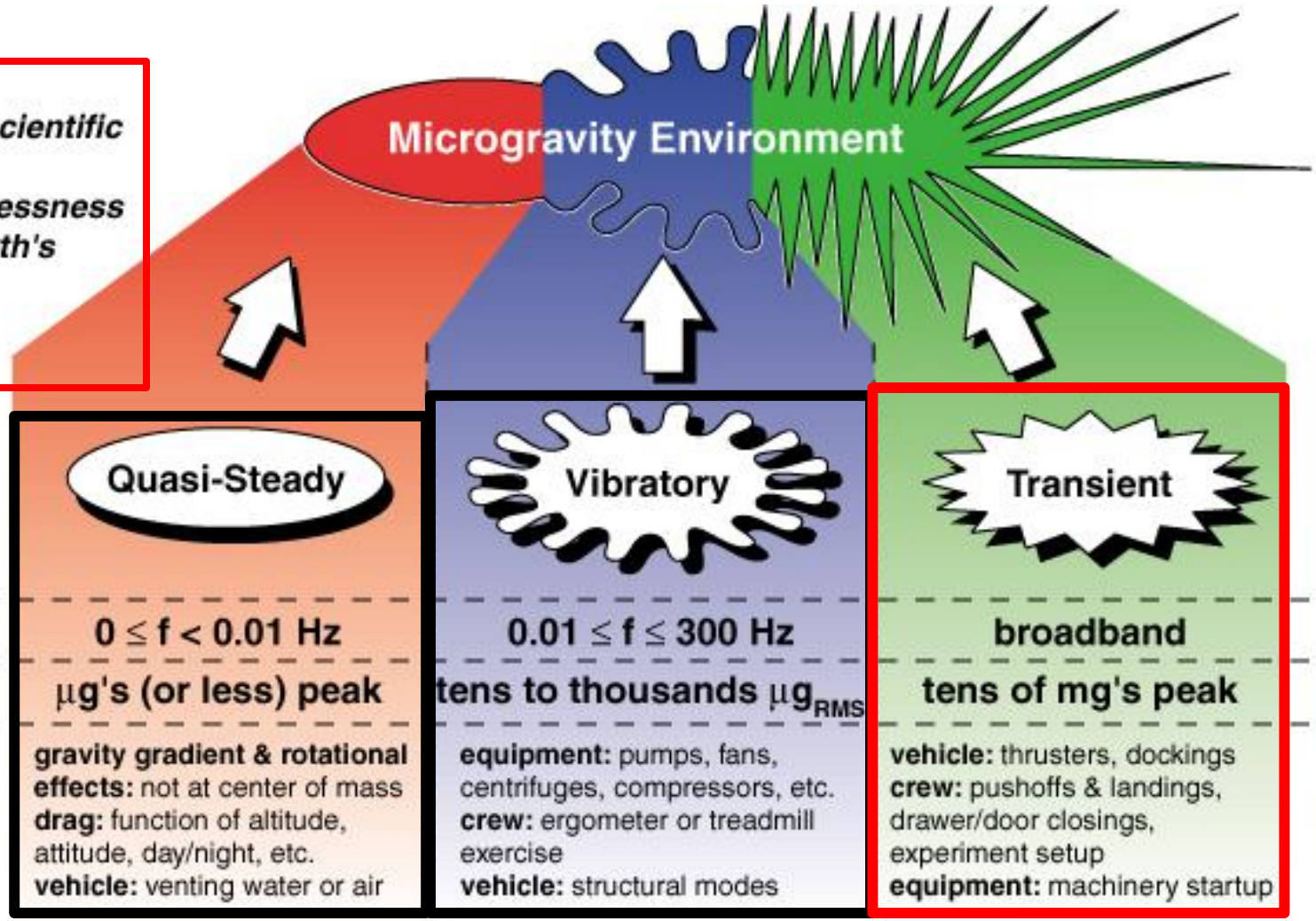
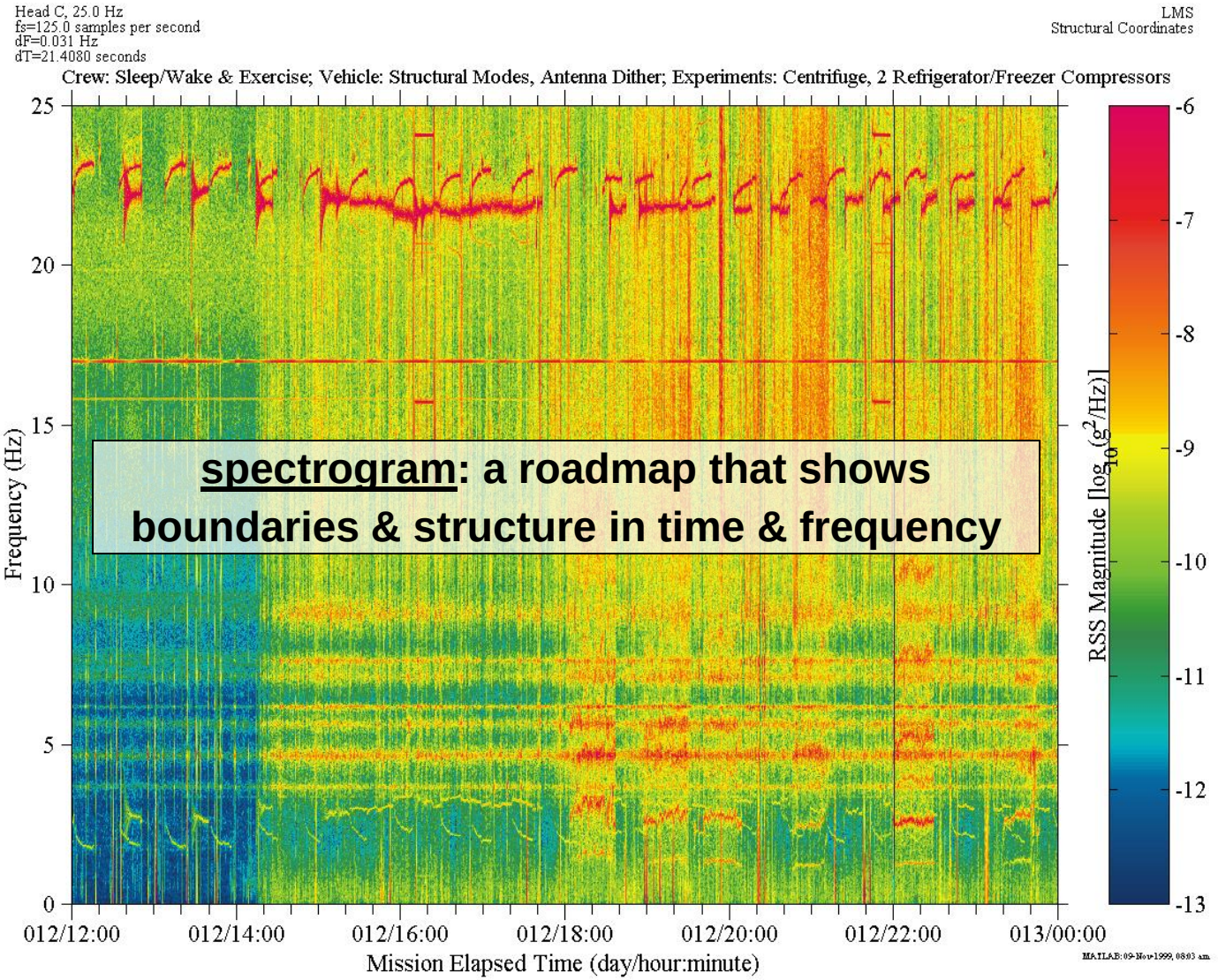
# Overview of Microgravity Environment

***Microgravity is:***
- ***a general label for scientific investigations that exploit near-weightlessness***
- ***one-millionth of Earth's normal gravity***
- ***a reduced gravity environment***

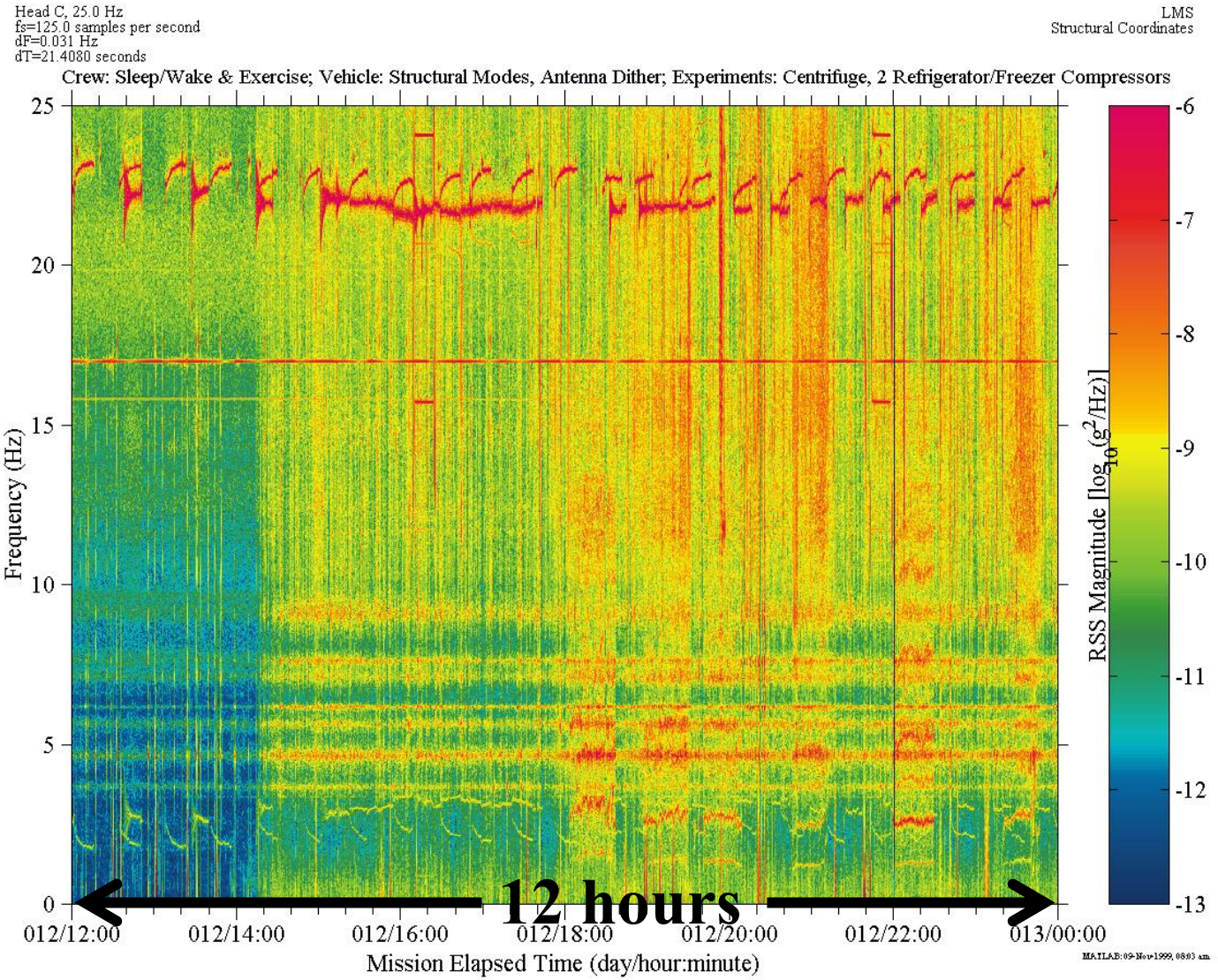


# Basic Characterization



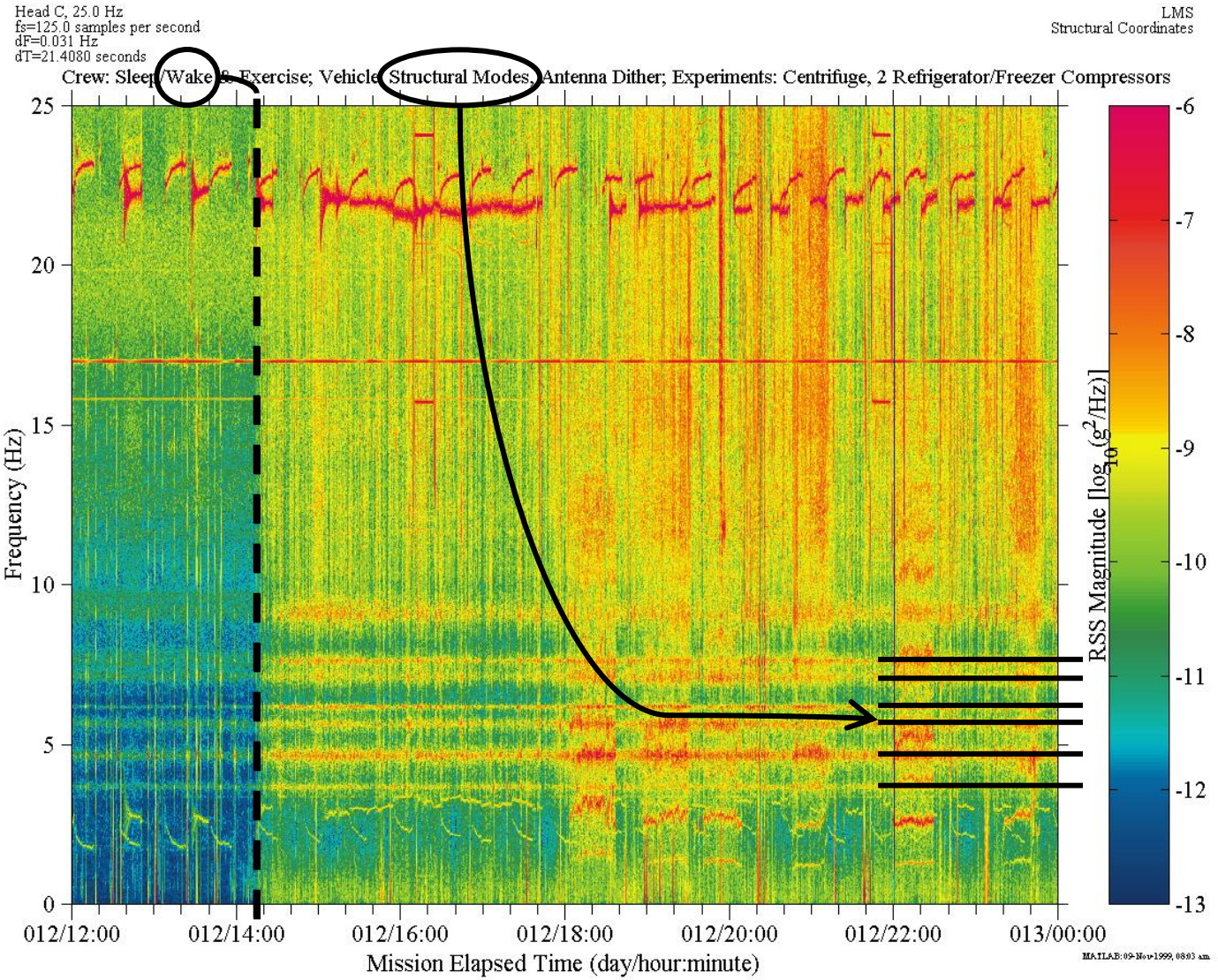
# Basic Characterization

**spectrogram: a roadmap that shows boundaries & structure in time & frequency**



# Basic Characterization

**spectrogram: a roadmap that shows boundaries & structure in time & frequency**



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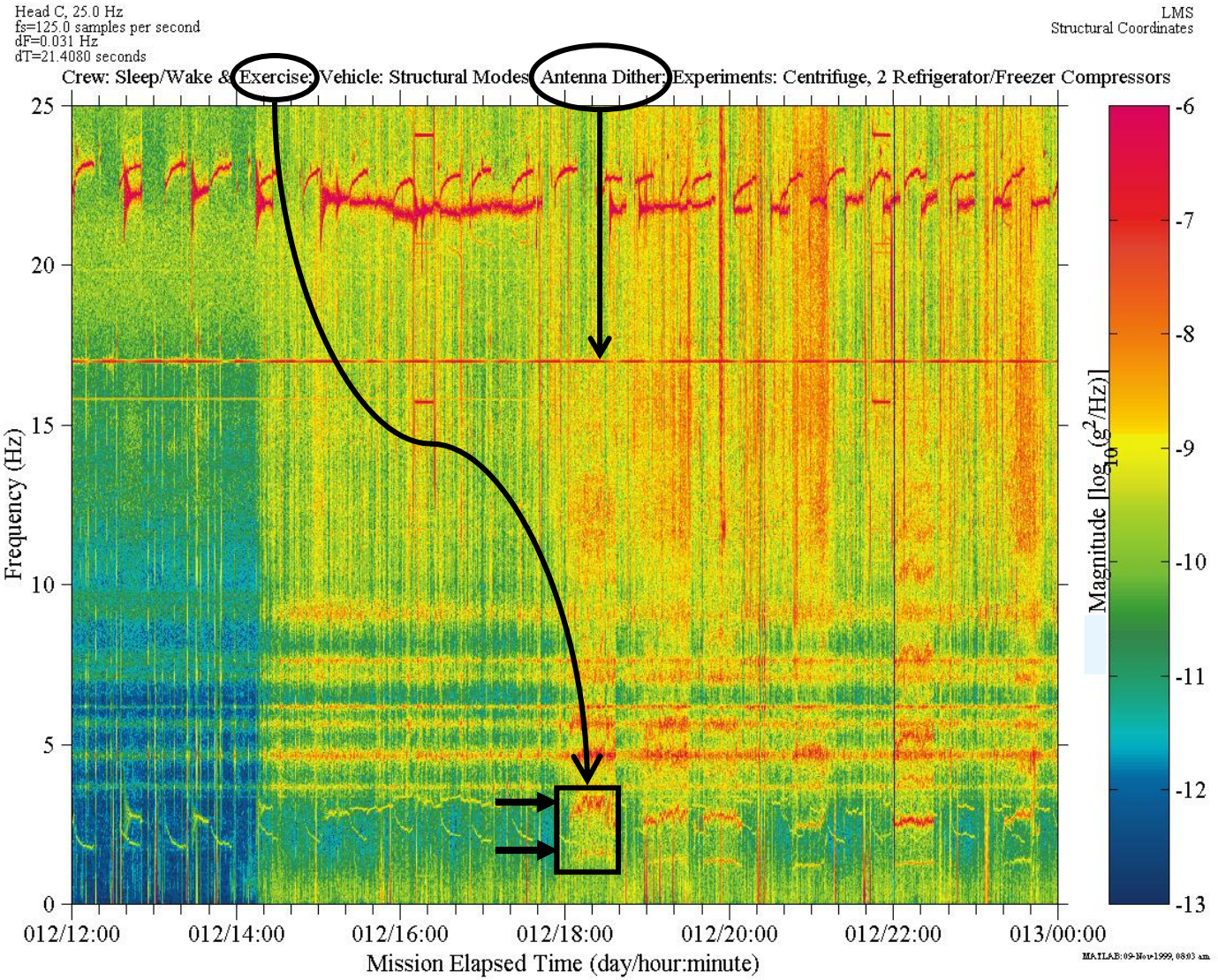
# Basic Characterization

**spectrogram: a roadmap that shows boundaries & structure in time & frequency**



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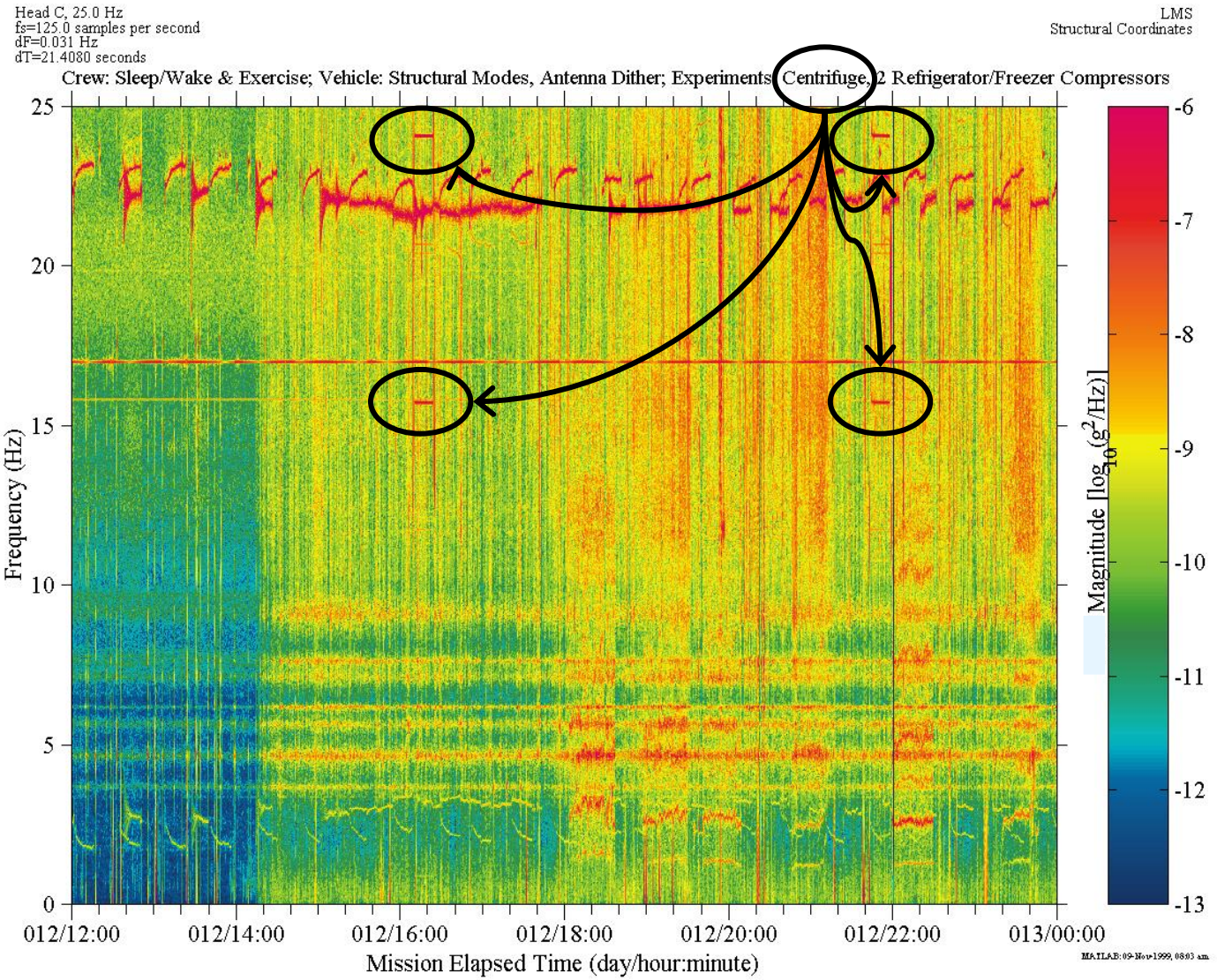
# Basic Characterization

**spectrogram: a roadmap that shows boundaries & structure in time & frequency**



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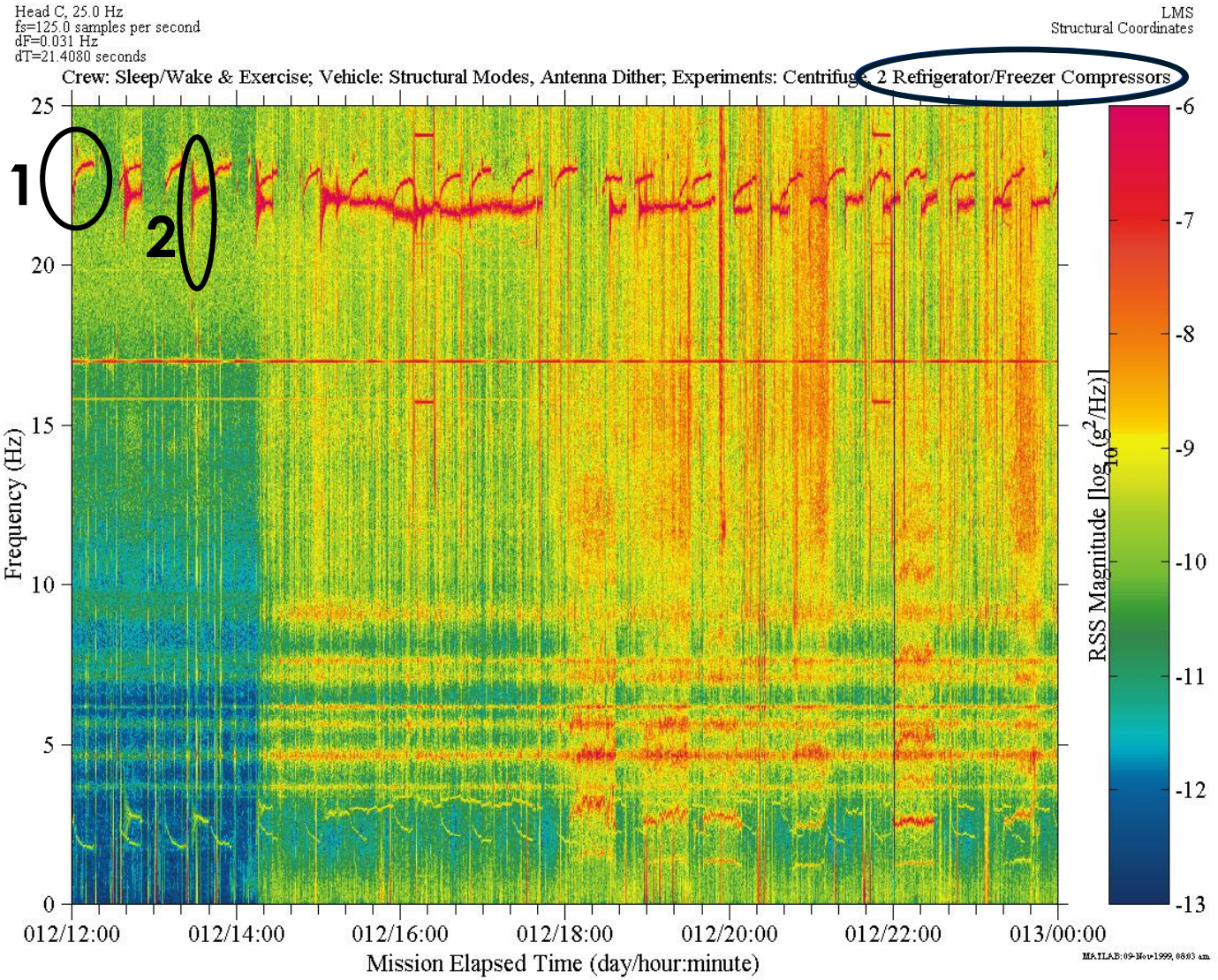
# Basic Characterization

**spectrogram: a roadmap that shows boundaries & structure in time & frequency**



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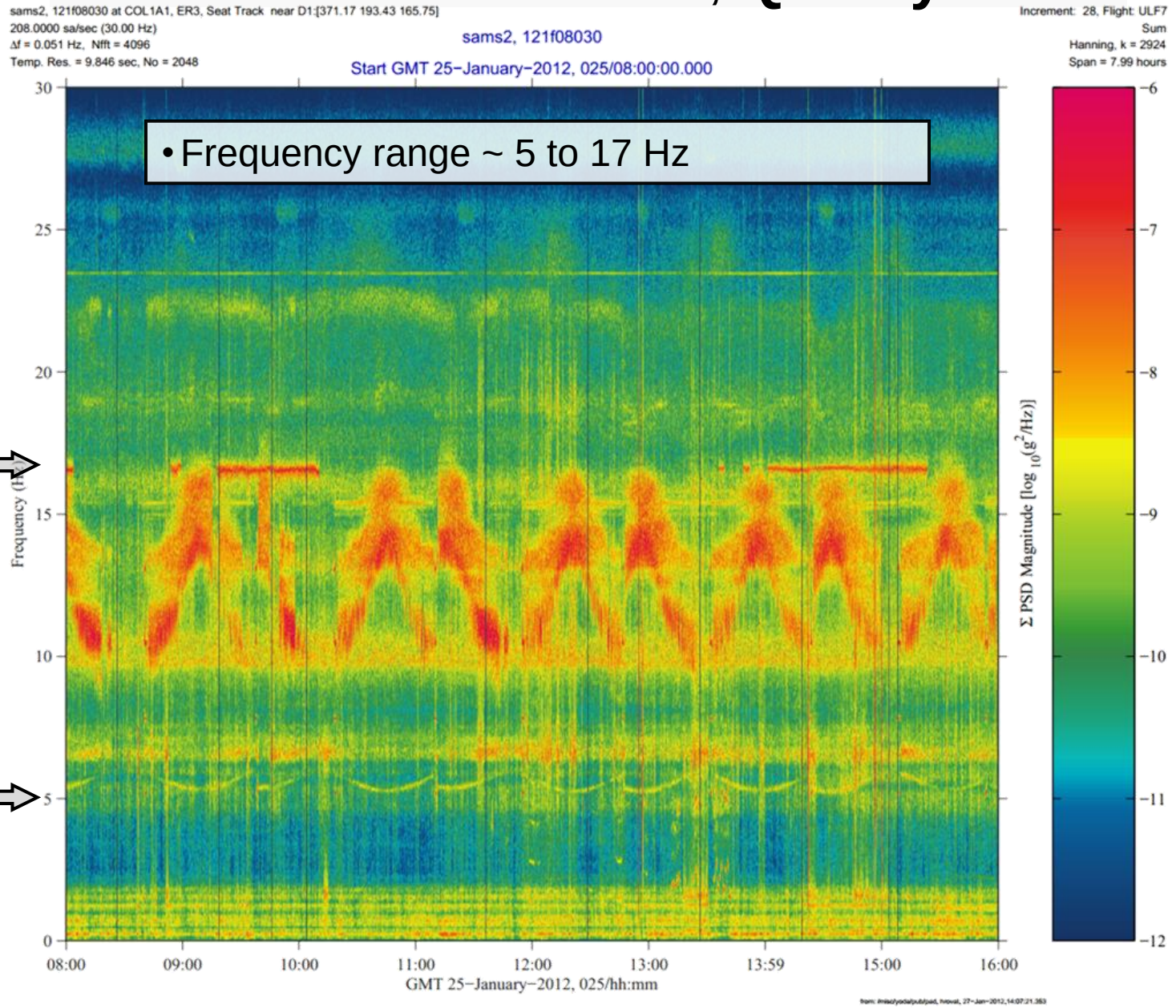
# Ku-Band Antenna, **Qualify**



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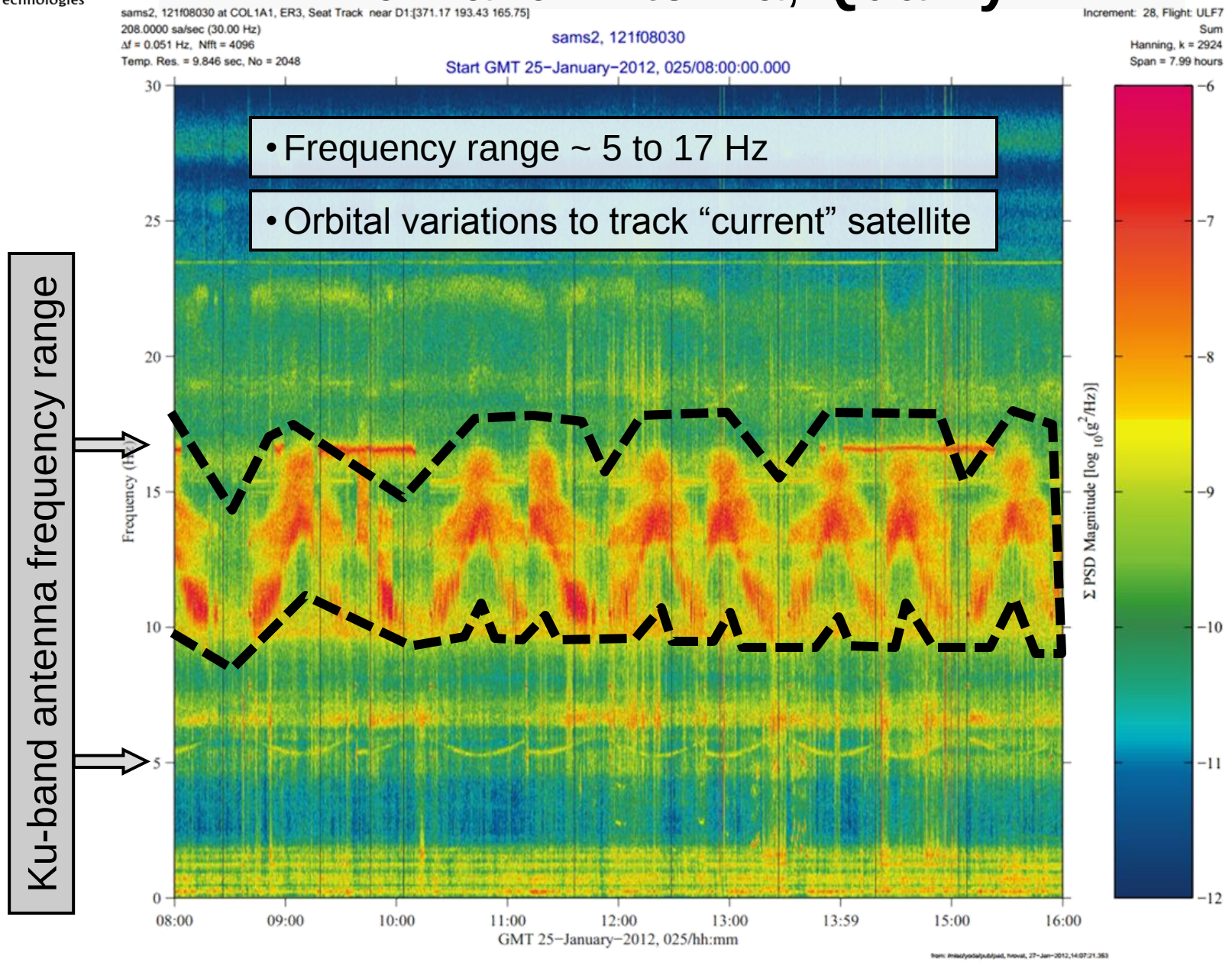
# Ku-Band Antenna, **Qualify**



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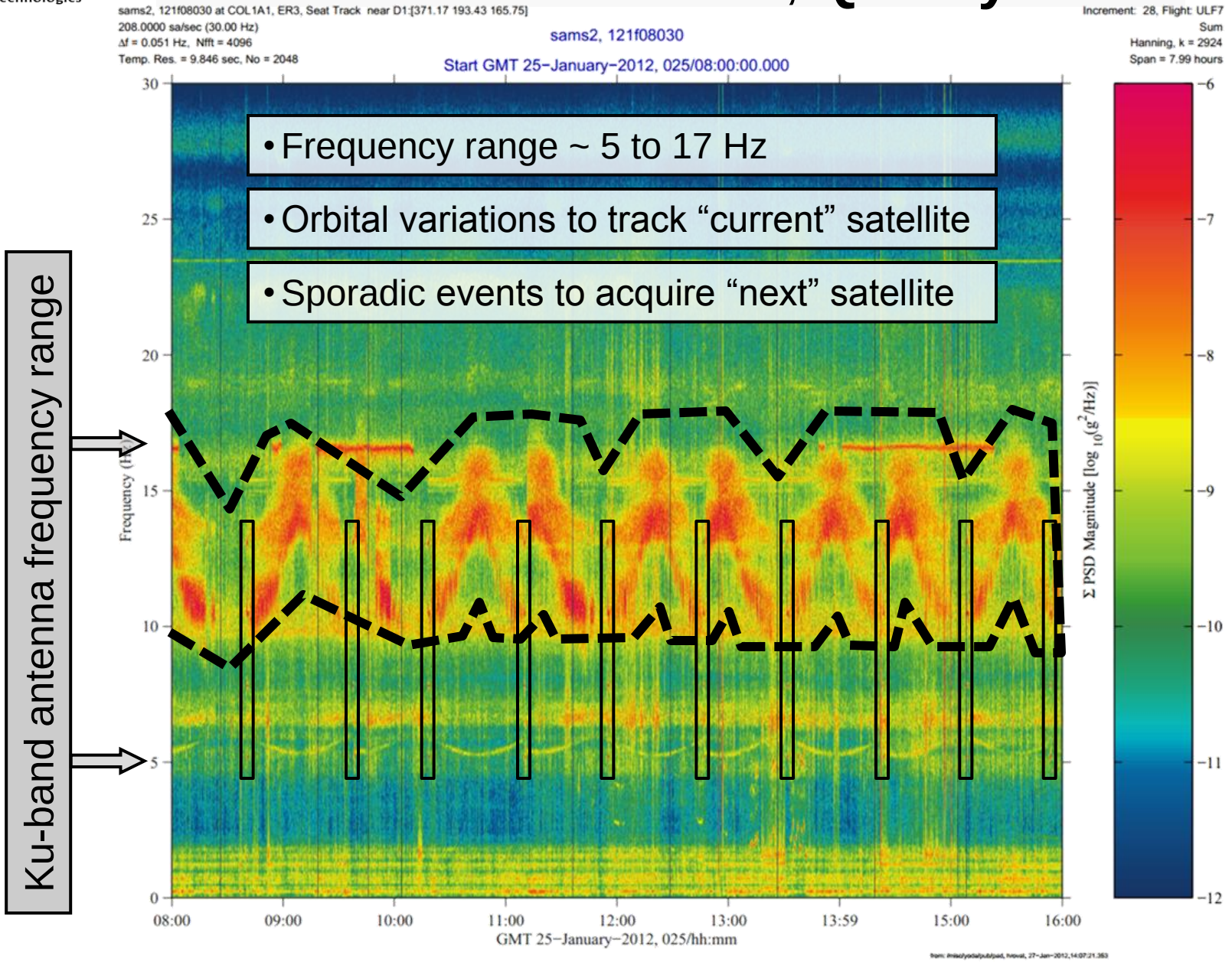

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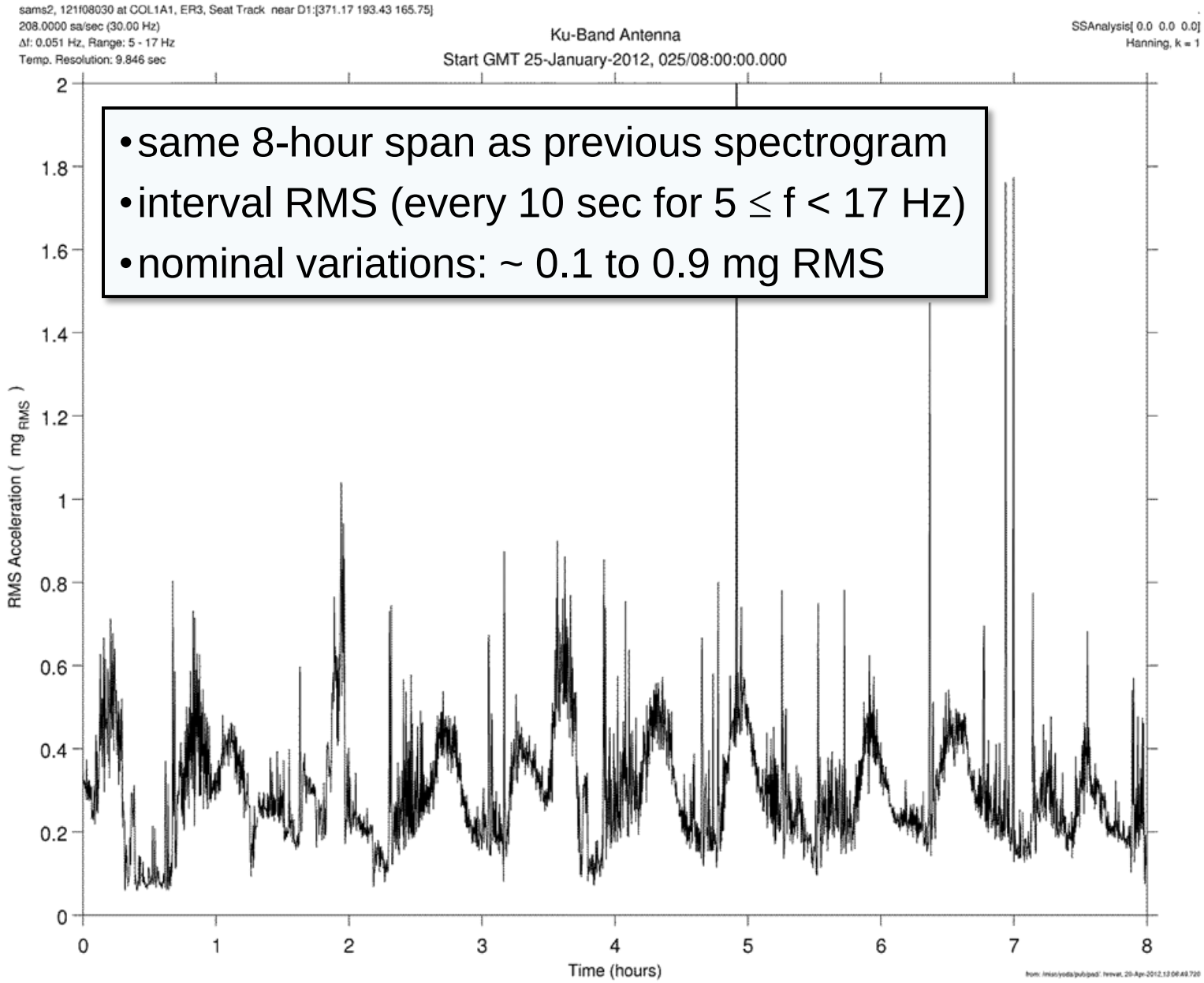
# Ku-Band Antenna, **Quantify**




- same 8-hour span as previous spectrogram
- interval RMS (every 10 sec for $5 \leq f < 17$ Hz)
- nominal variations: ~ 0.1 to 0.9 mg RMS

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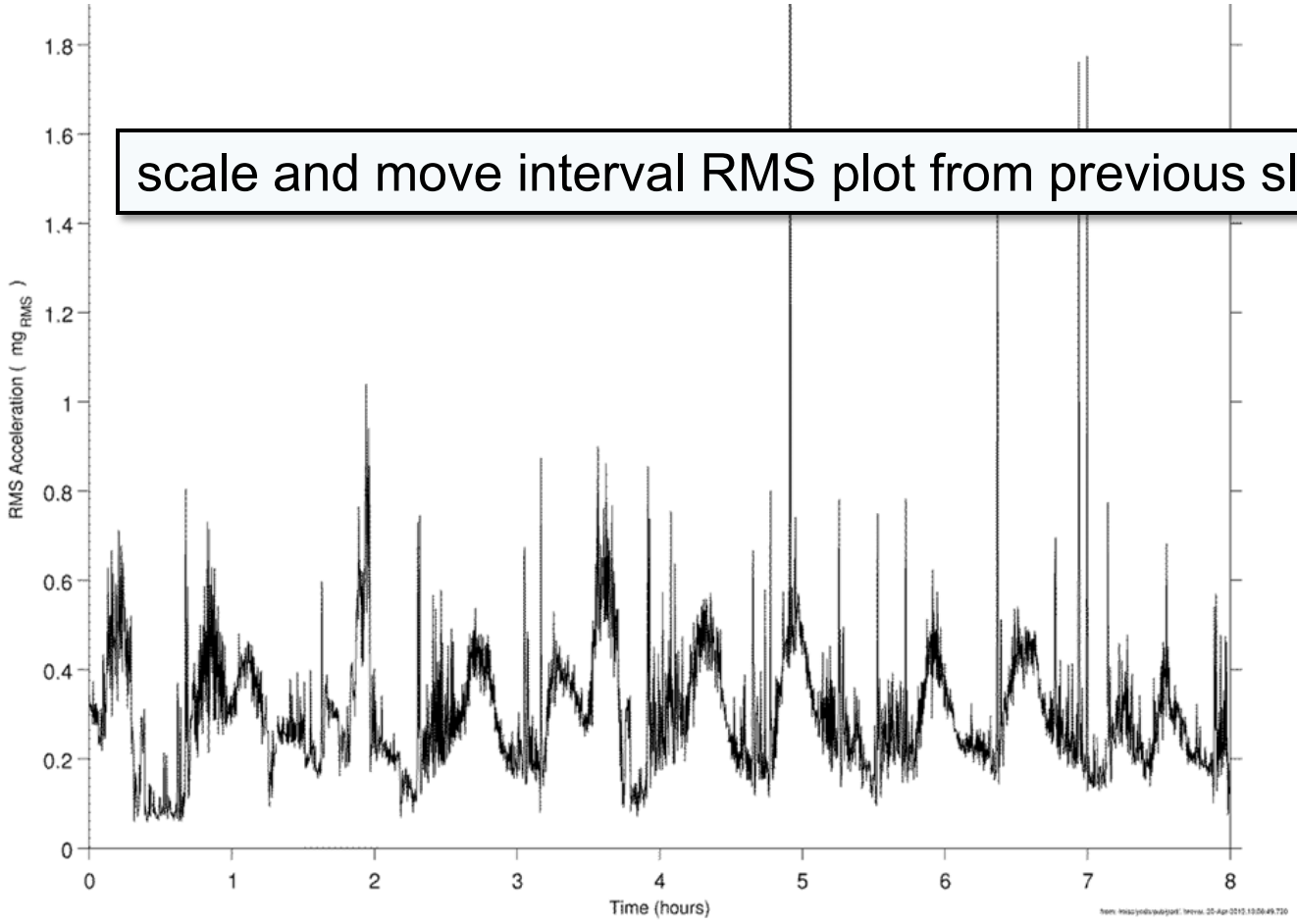
# Ku-Band Antenna, **Quantify**

scale and move interval RMS plot from previous slide…



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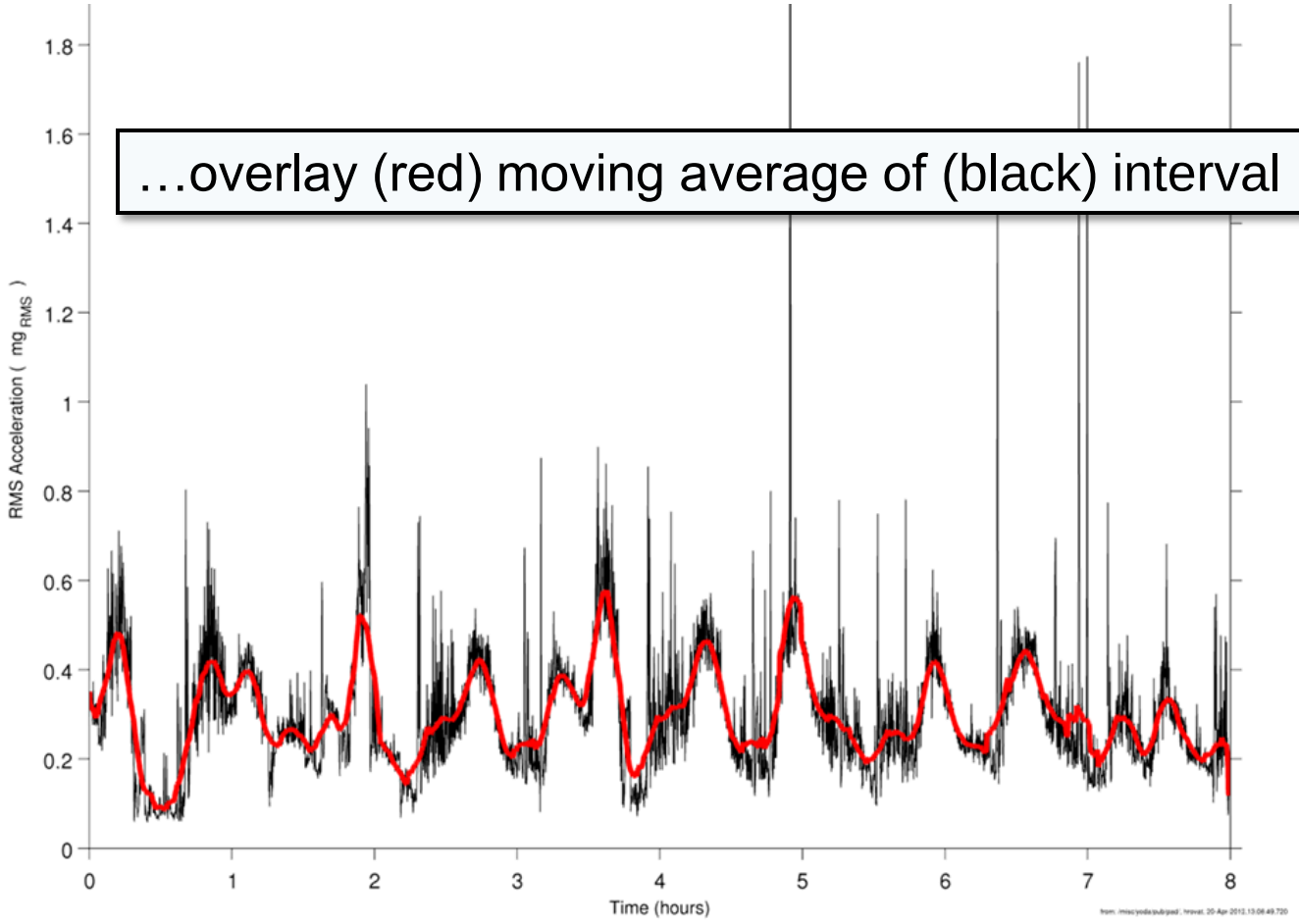
# Ku-Band Antenna, **Quantify**

…overlay (red) moving average of (black) interval RMS…



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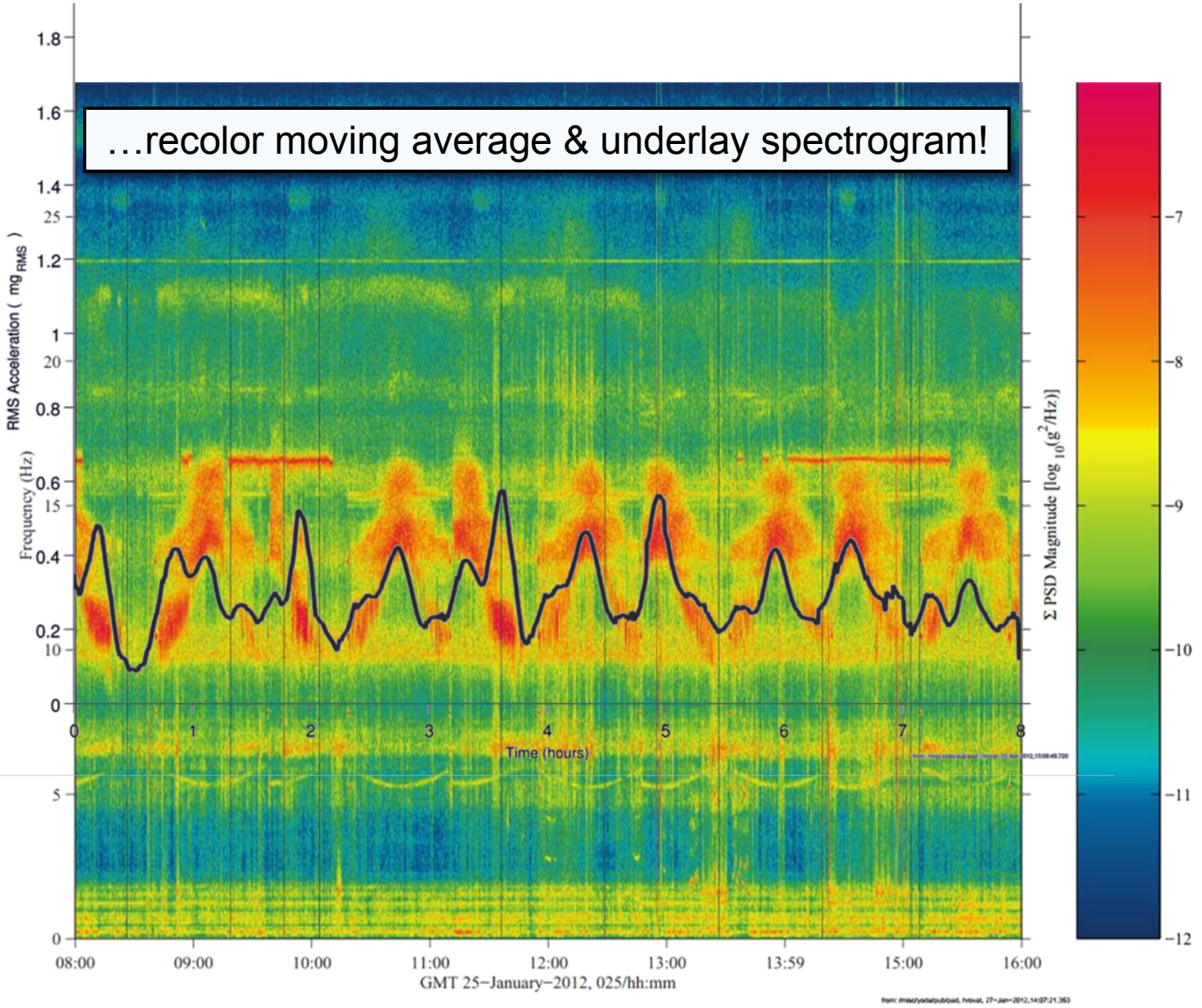
# Ku-Band Antenna, **Quantify**



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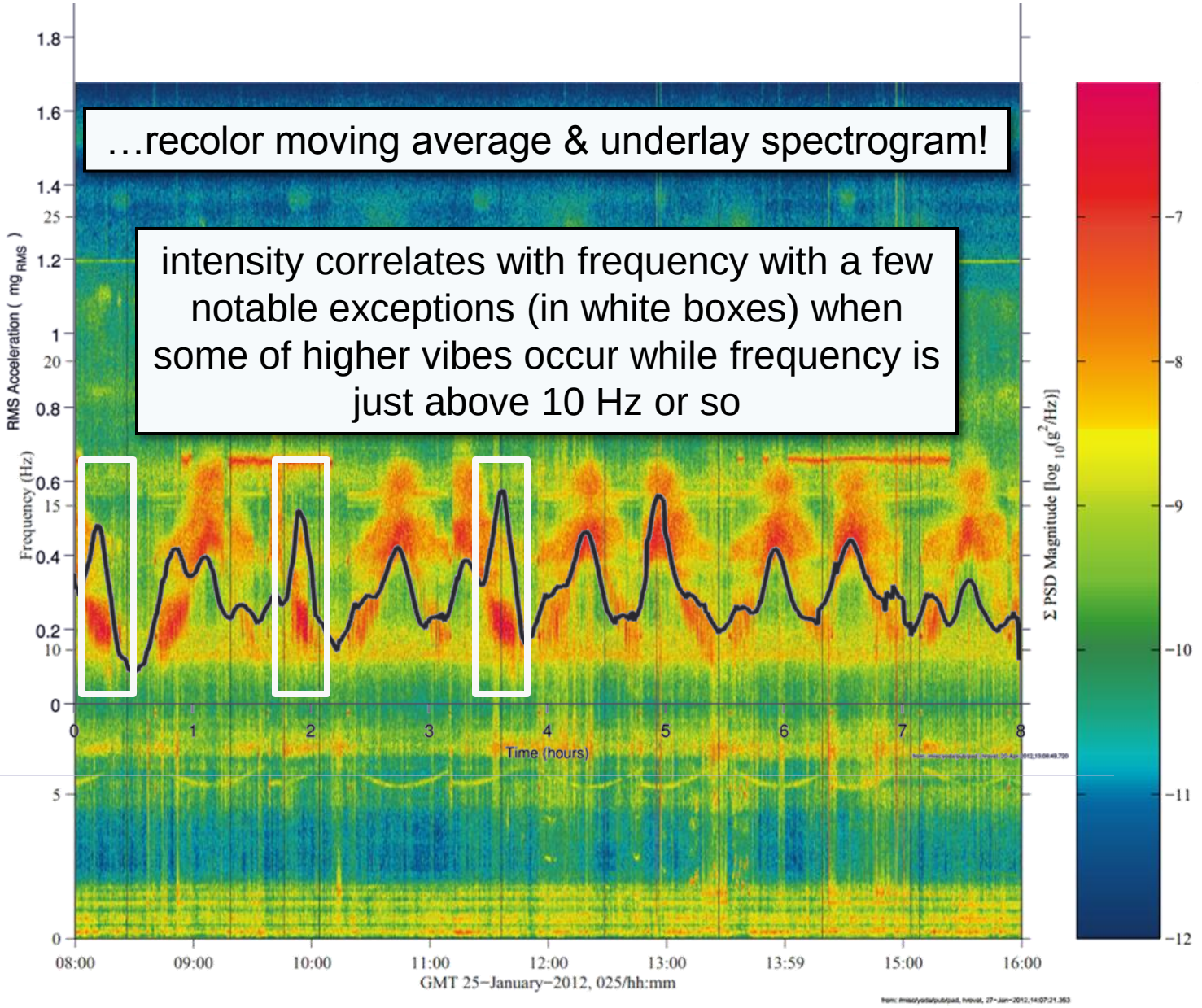
# Ku-Band Antenna, **Quantify**



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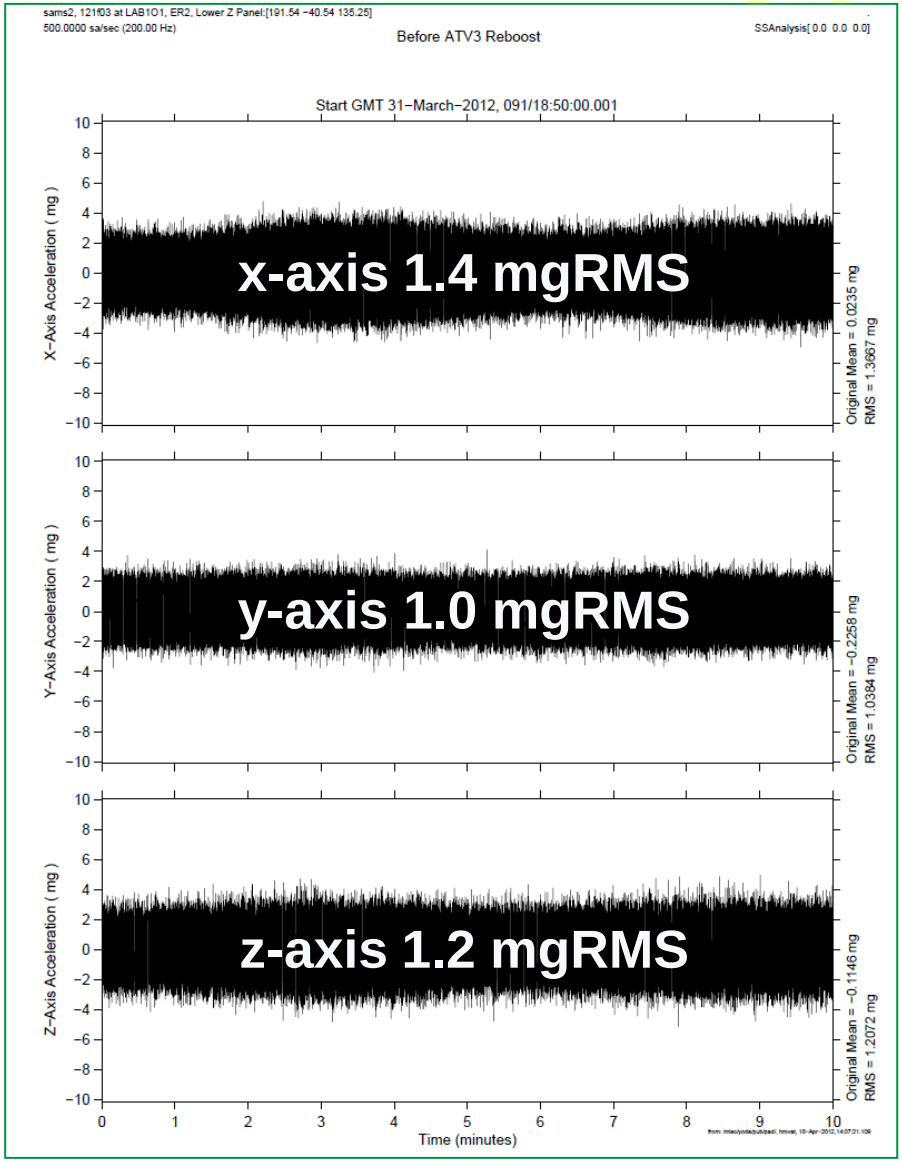
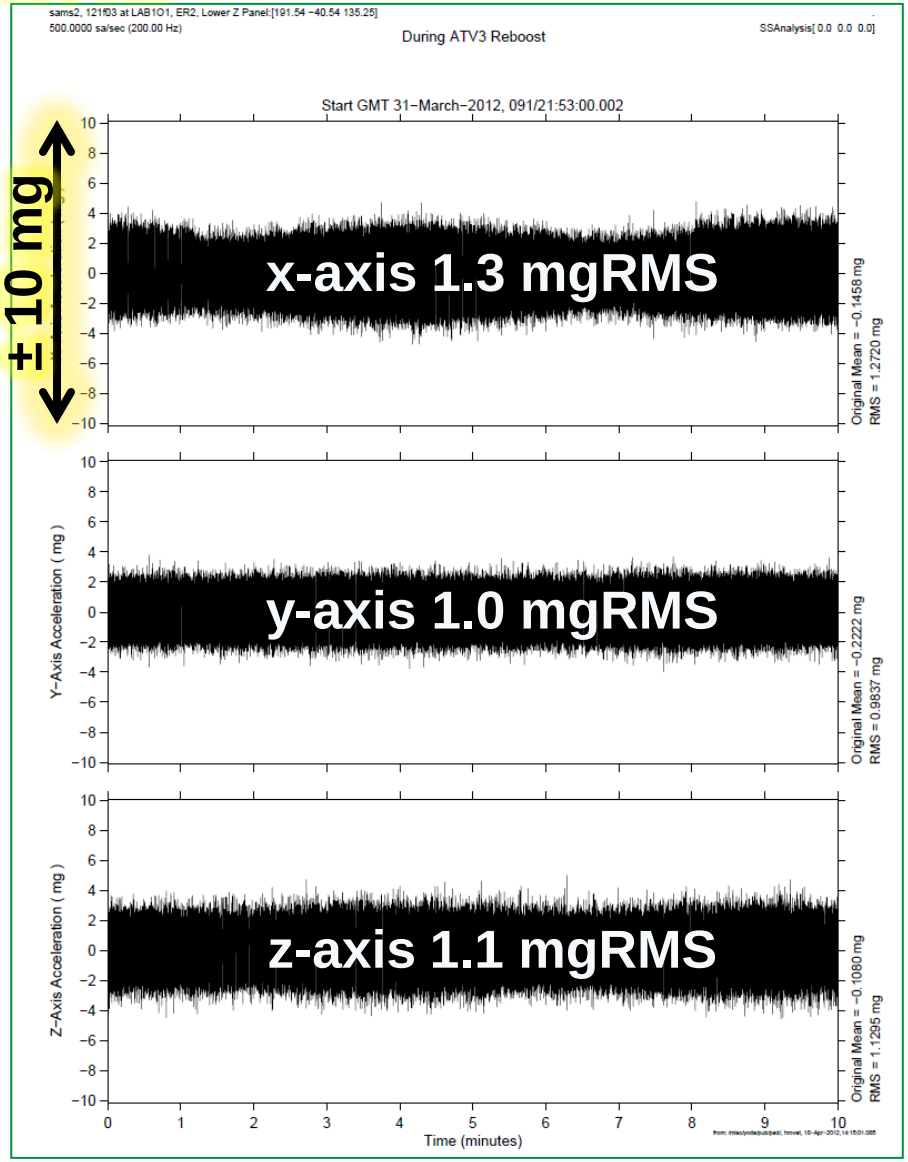
# ATV3 Reboost GMT 31-Mar-2012

**BEFORE** **0 < f < 200 Hz** **DURING**



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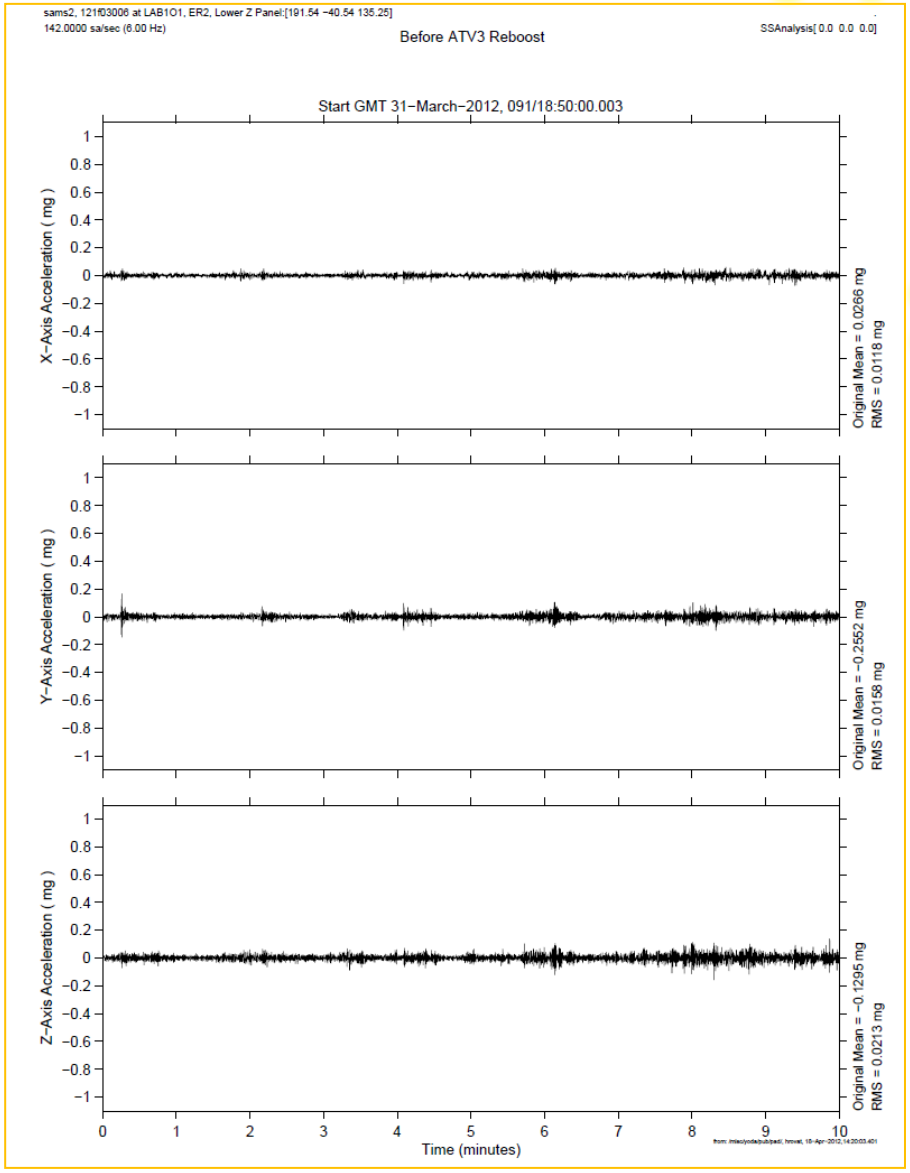
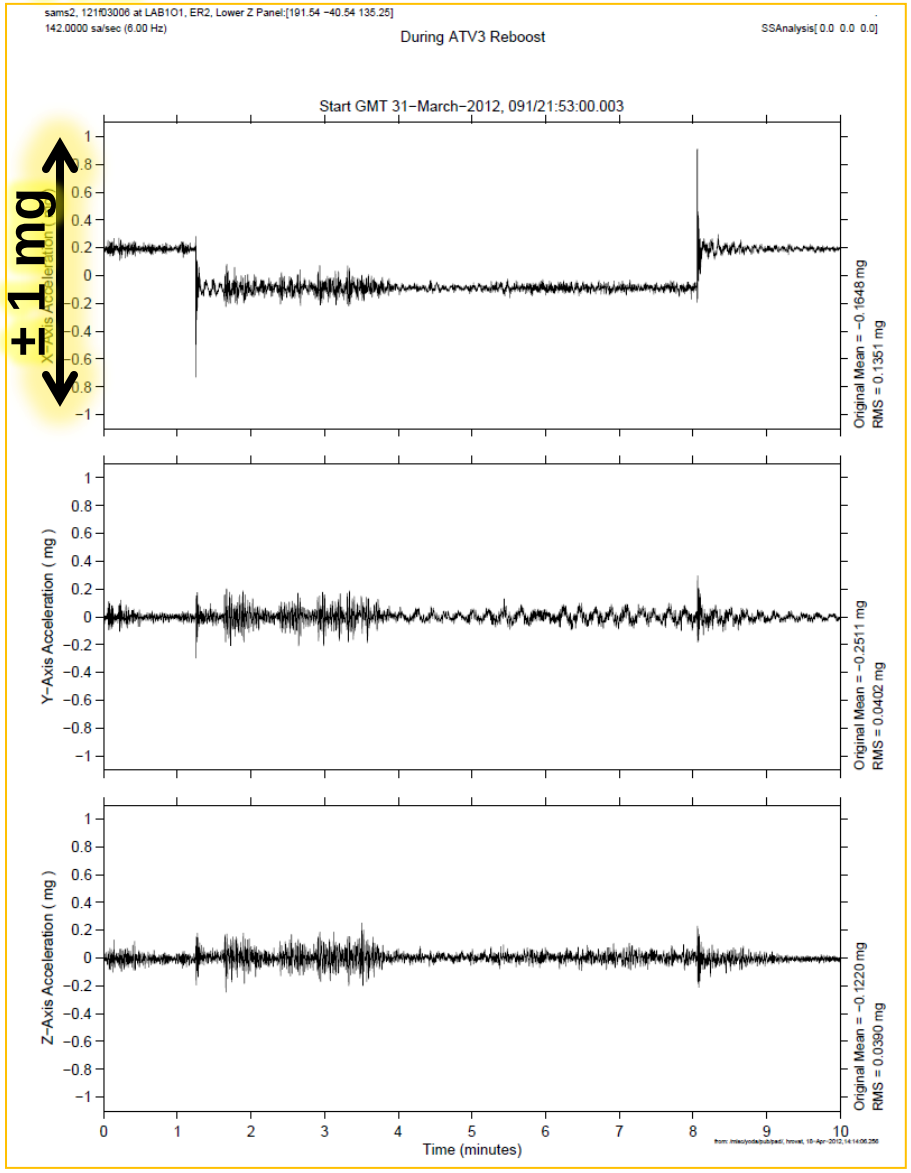
# ATV3 Reboost GMT 31-Mar-2012

**BEFORE** **0 < f < 6 Hz** **DURING**



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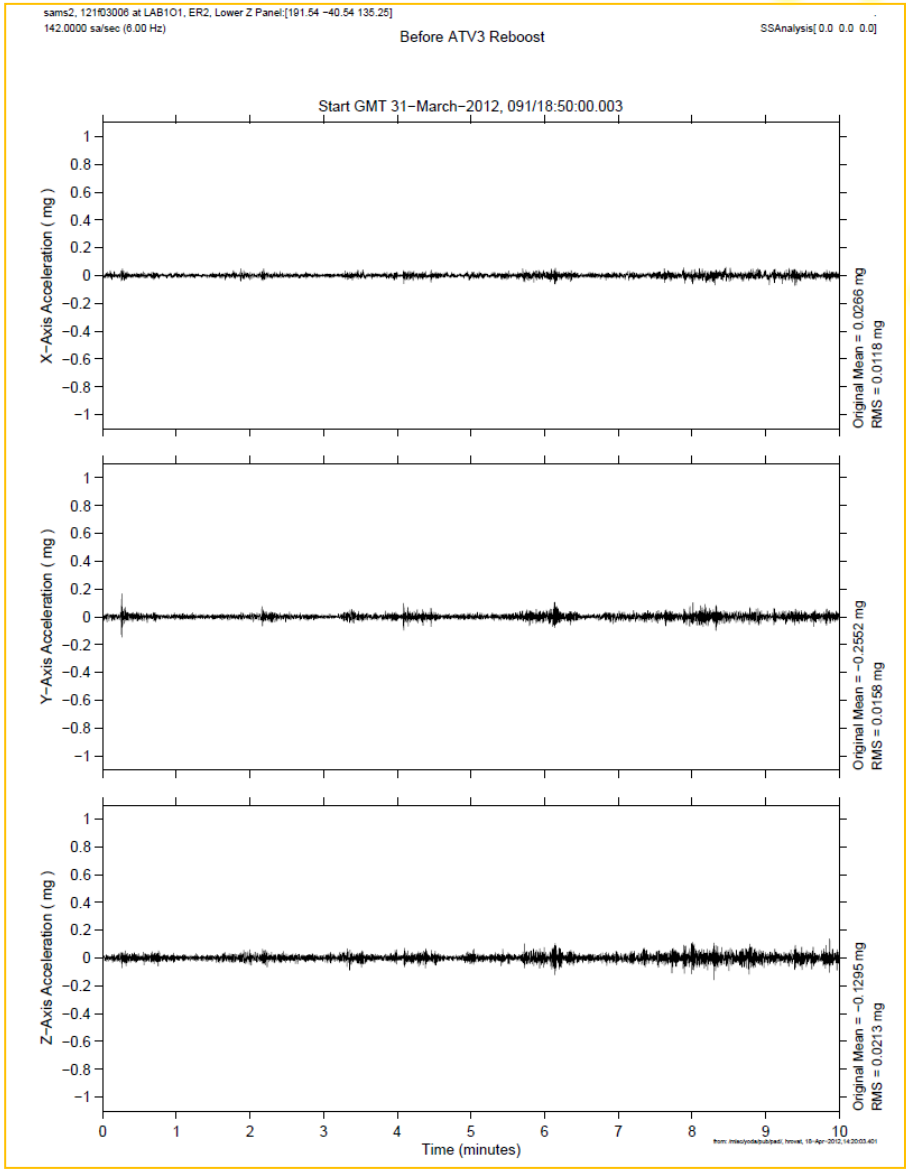
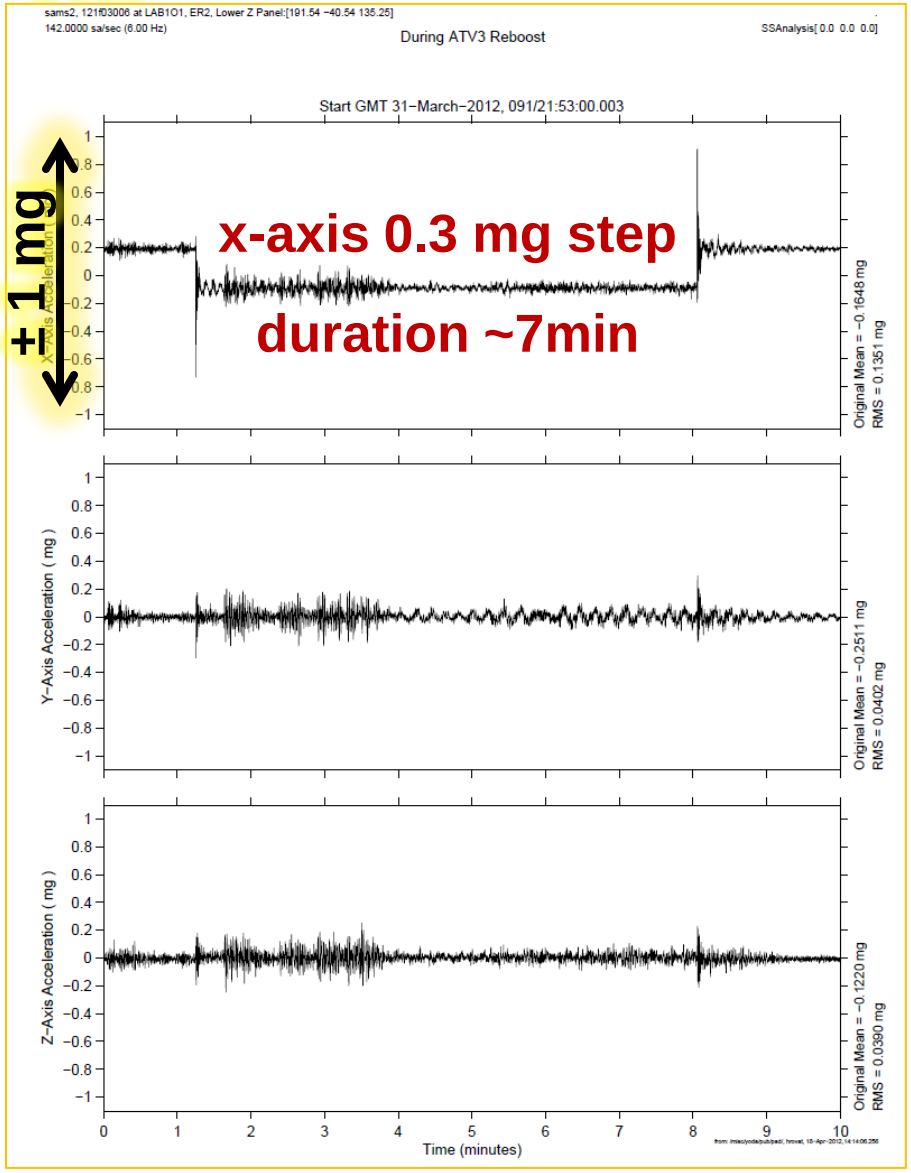
# ATV3 Reboost GMT 31-Mar-2012

**BEFORE** **0 < f < 6 Hz** **DURING**

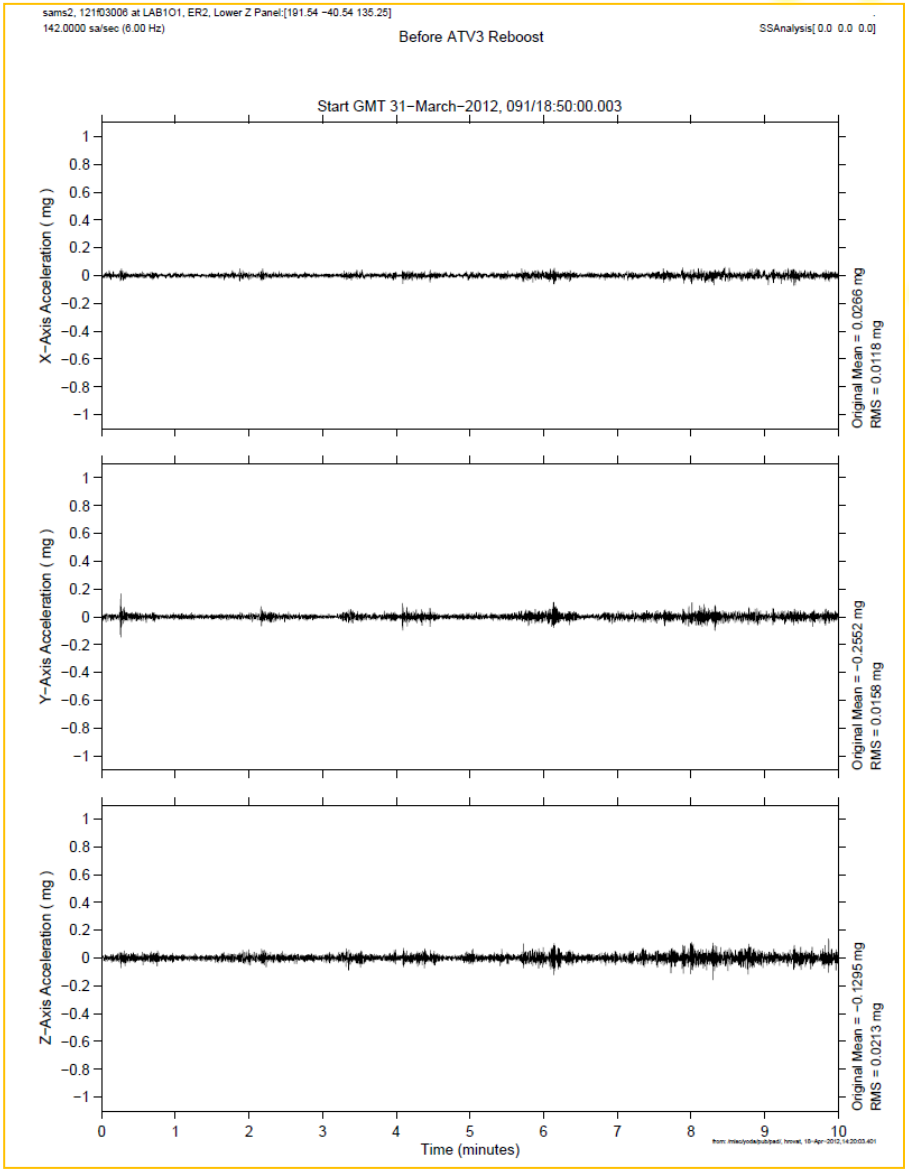


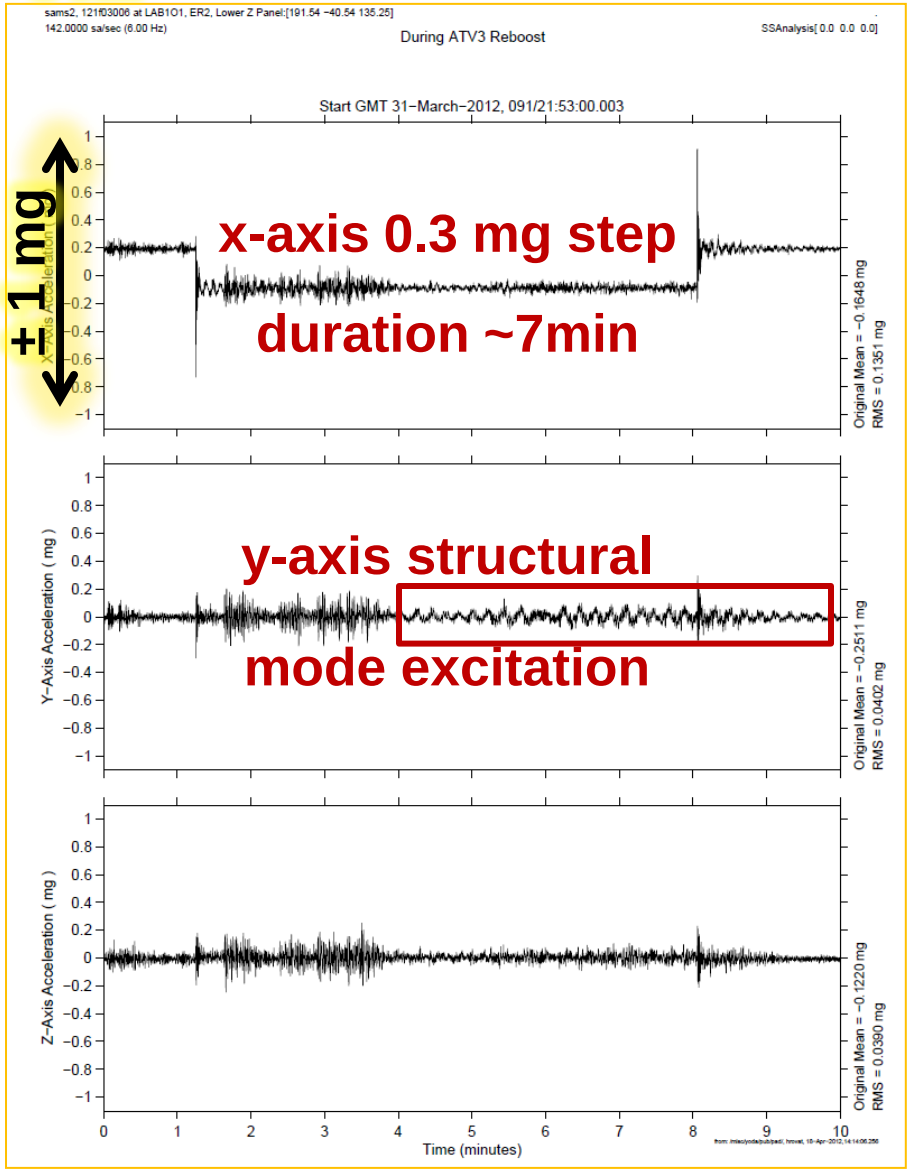



ZIN Technologies

# ATV3 Reboost GMT 31-Mar-2012

**BEFORE** **0 < f < 6 Hz** **DURING**



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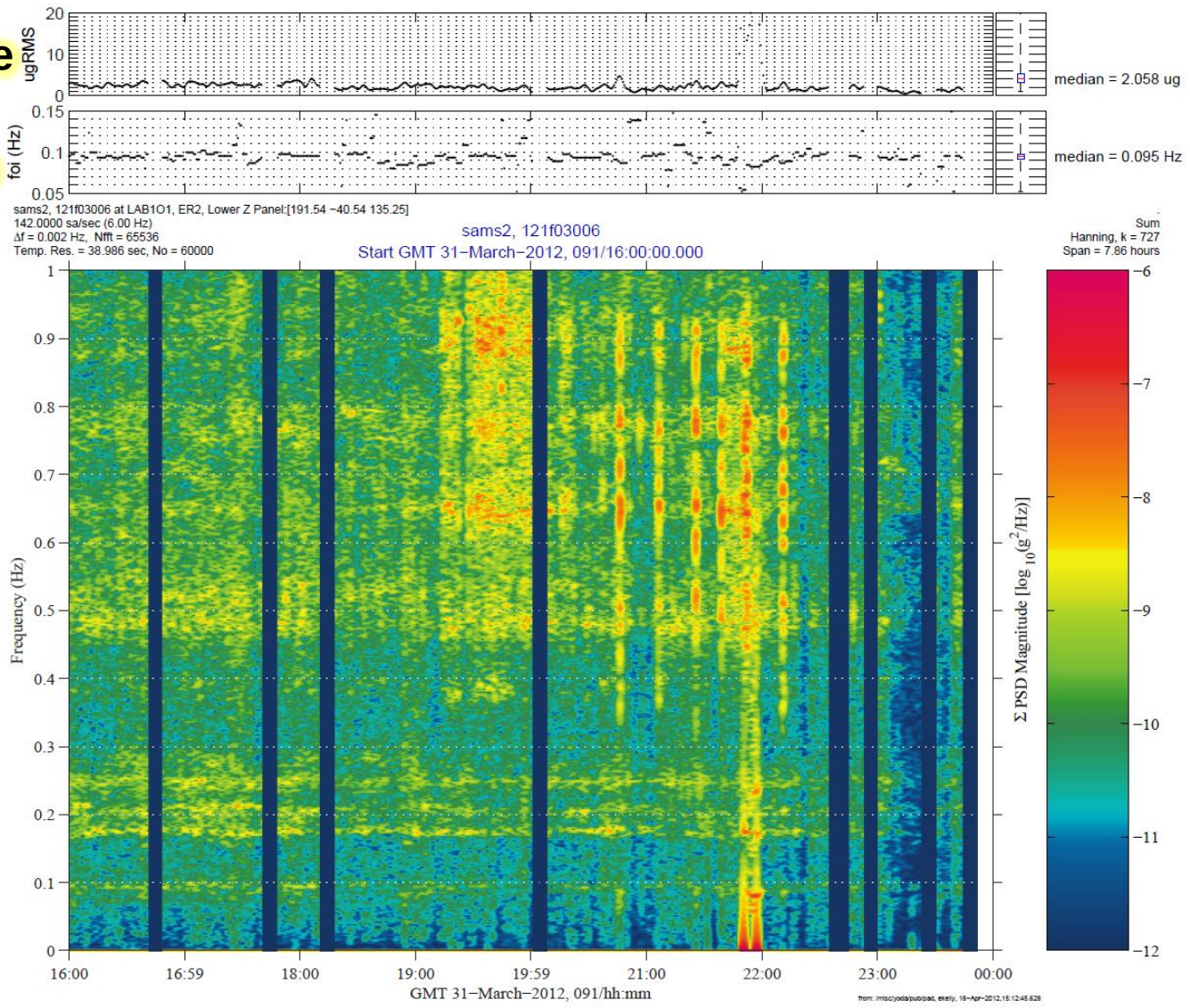
# ATV3 Reboost GMT 31-Mar-2012

**Top 2 subplots focus on max spectral peak between 0.05 ≤ f < 0.15 Hz**

**RMS value**

**freq @ max PSD**



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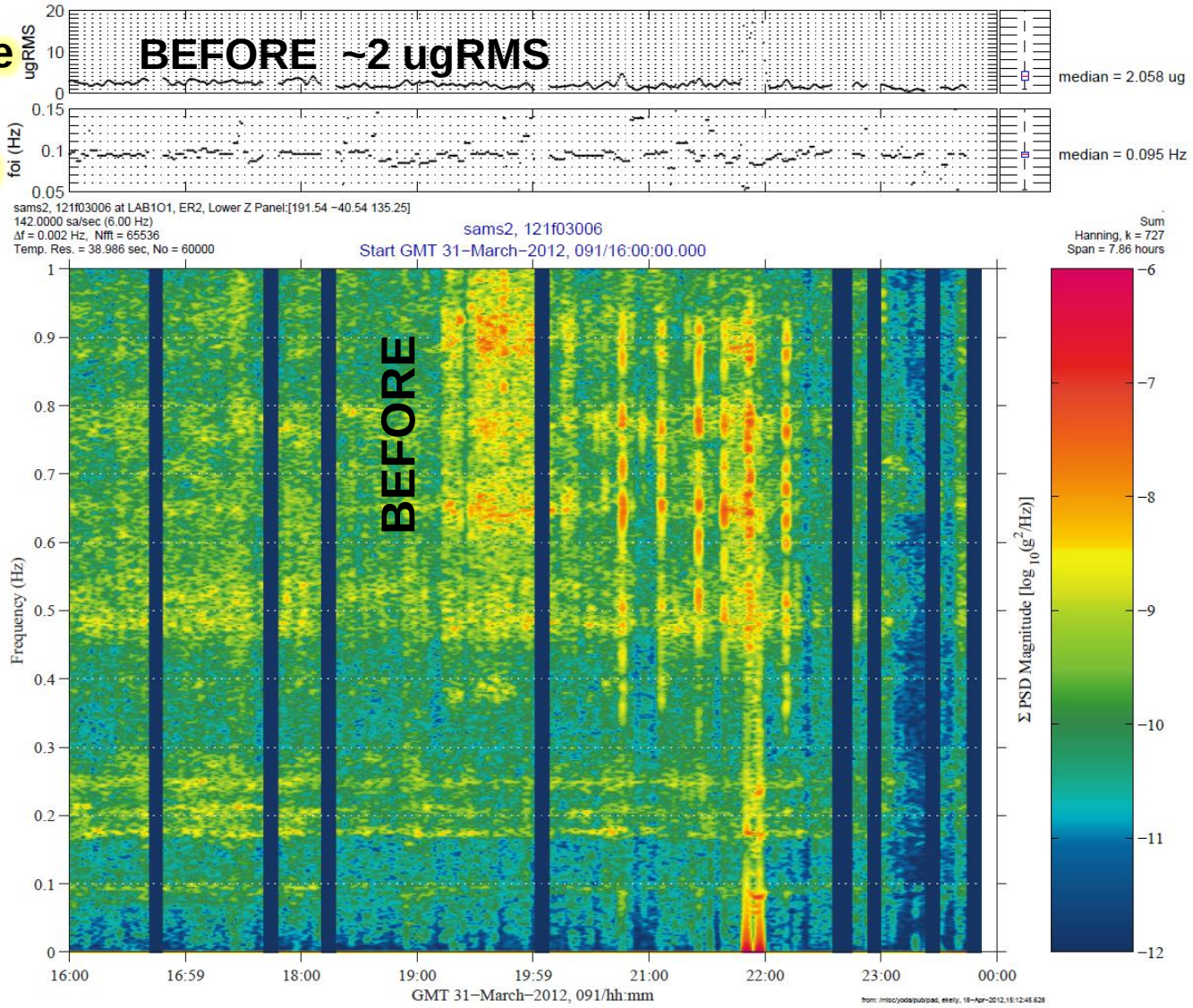
# ATV3 Reboost GMT 31-Mar-2012

**Top 2 subplots focus on max spectral peak between 0.05 ≤ f < 0.15 Hz**

**RMS value**

**freq @ max PSD**



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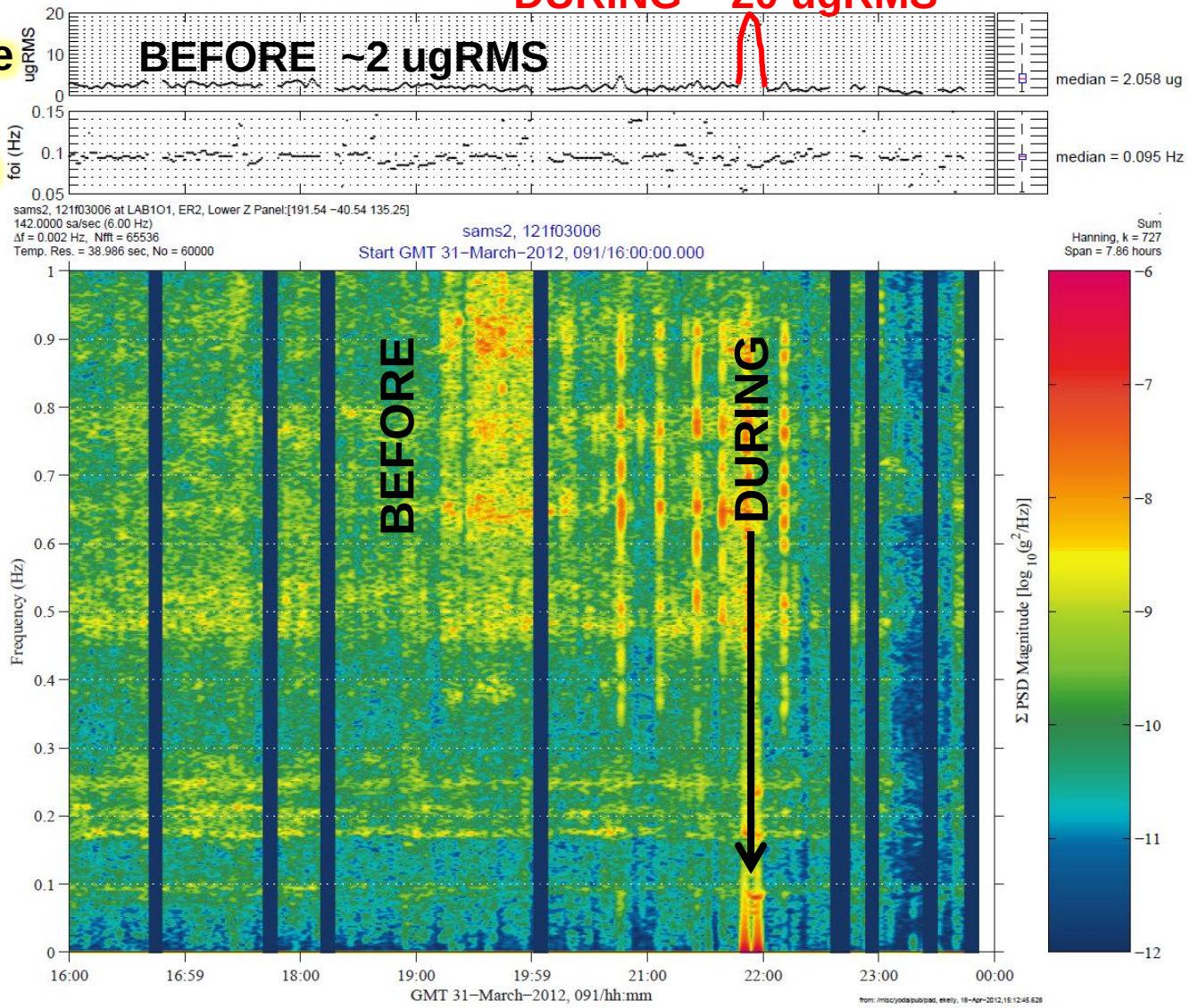
# ATV3 Reboost GMT 31-Mar-2012

**Top 2 subplots focus on max spectral peak between 0.05 ≤ f < 0.15 Hz**

**RMS value**

**freq @ max PSD**



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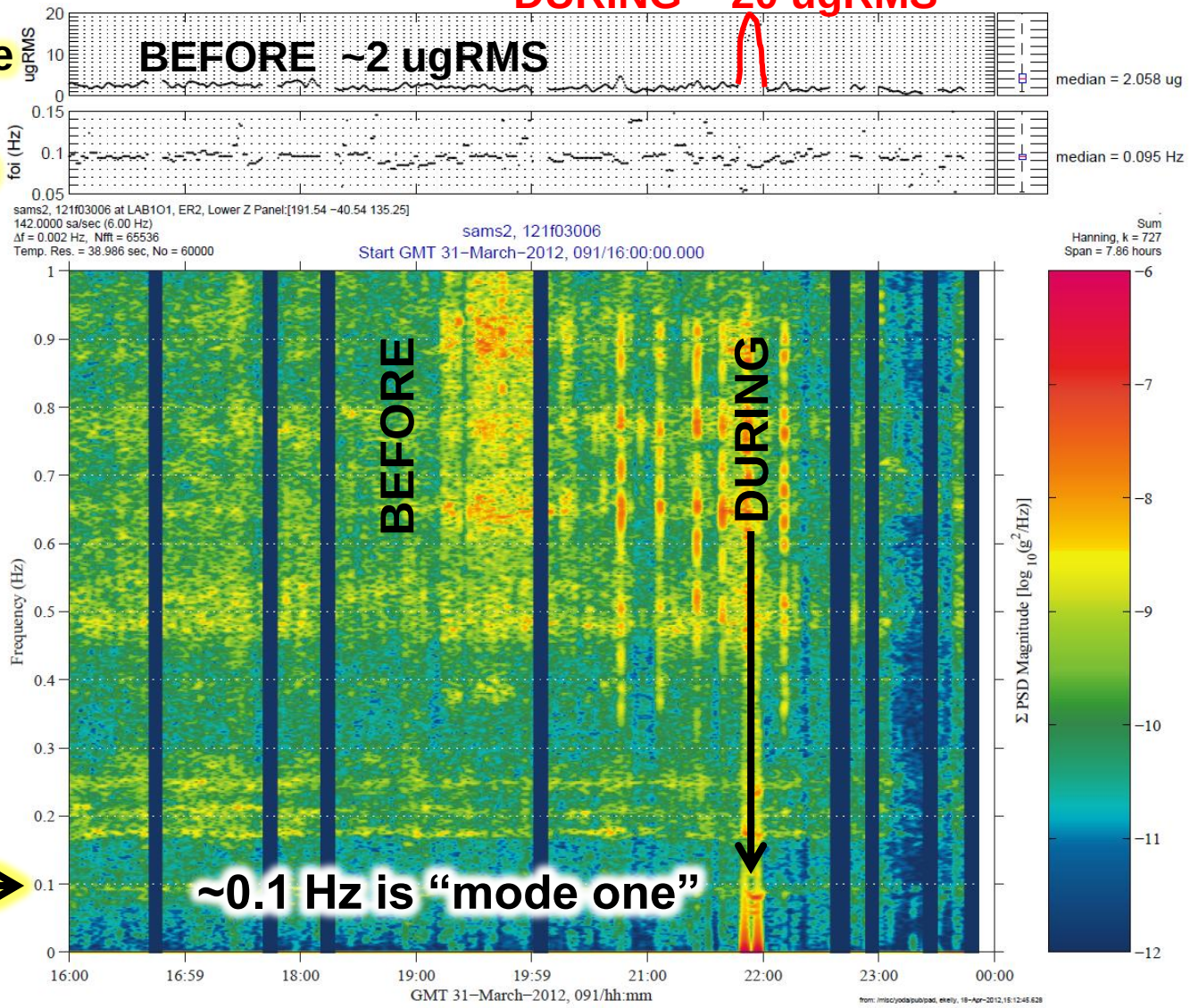
# ATV3 Reboost GMT 31-Mar-2012

**Top 2 subplots focus on max spectral peak between 0.05 ≤ f < 0.15 Hz**

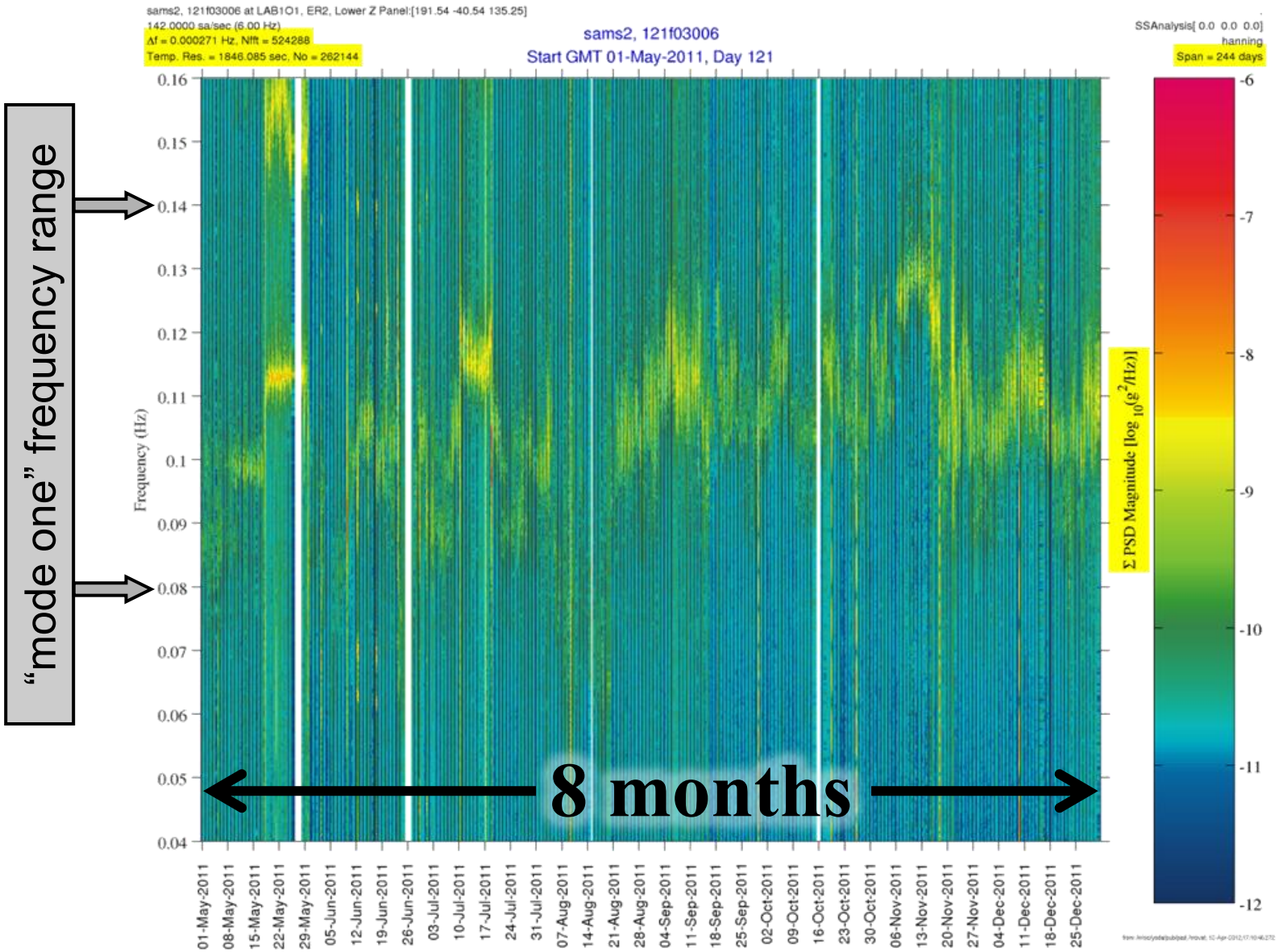
**DURING ~20 ugRMS**

**RMS value**

**freq @ max PSD**



# "Mode One" Analysis



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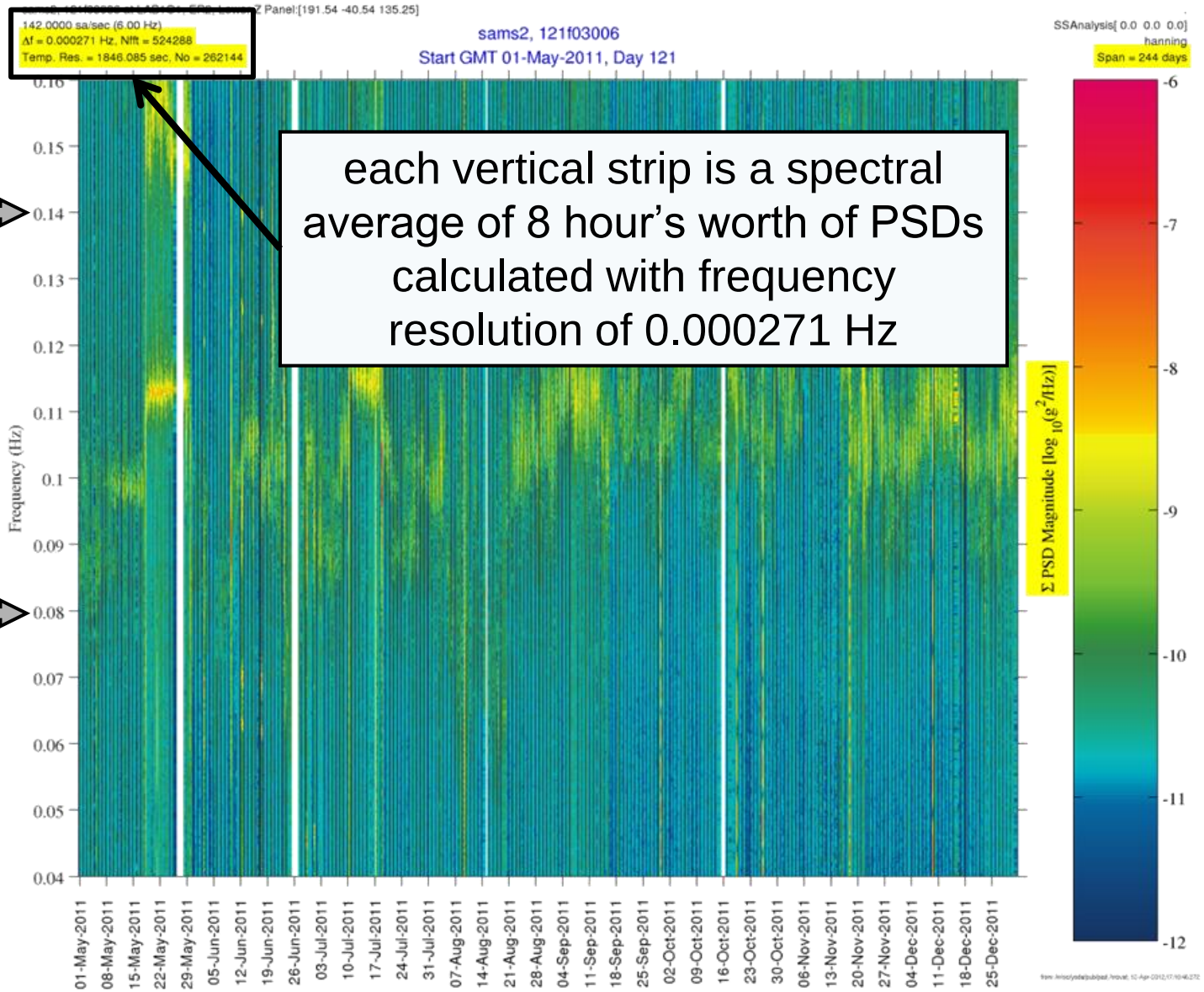
# "Mode One" Analysis

"mode one" frequency range




each vertical strip is a spectral average of 8 hour's worth of PSDs calculated with frequency resolution of 0.000271 Hz

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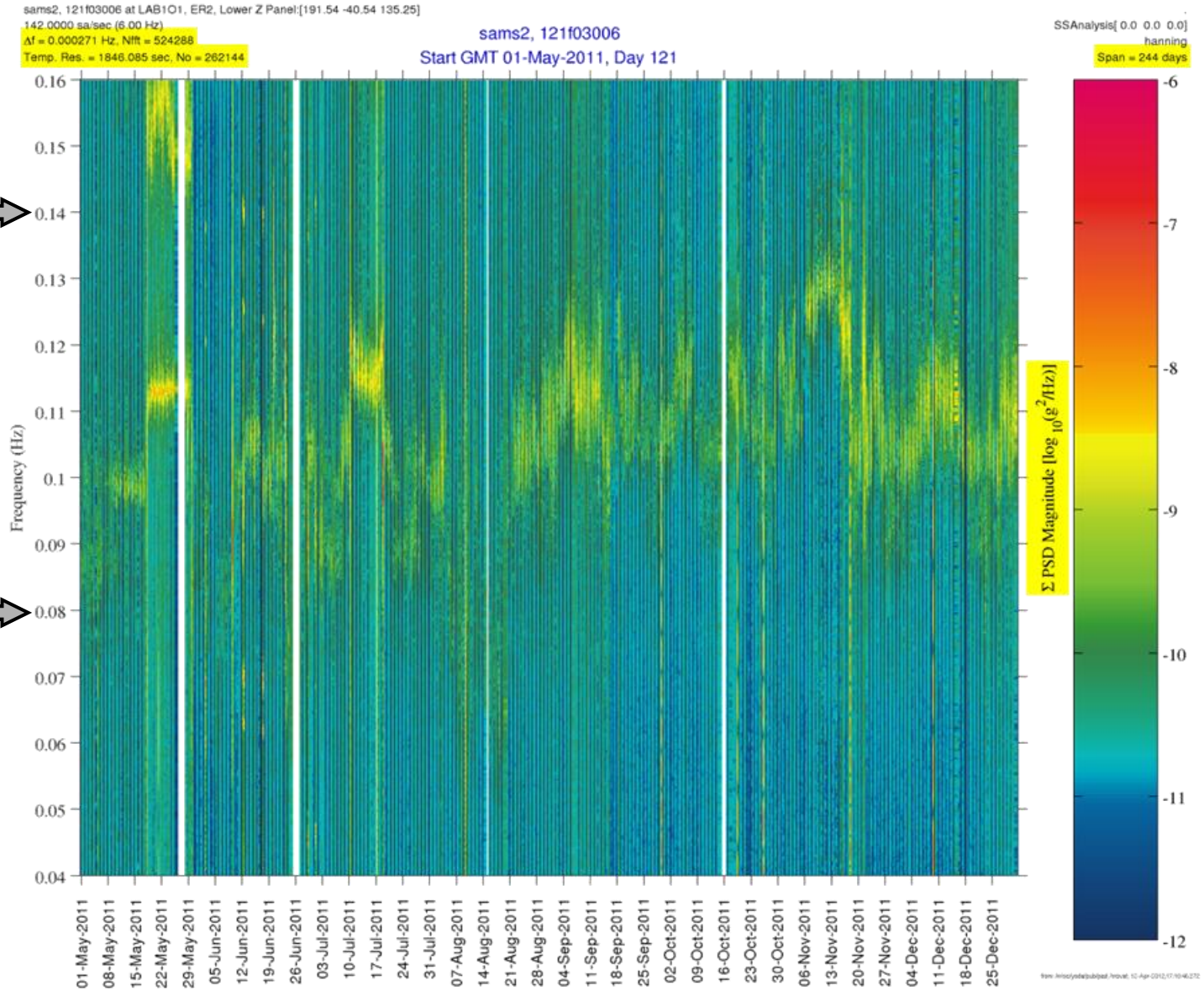
# “Mode One” Analysis

“mode one” frequency range



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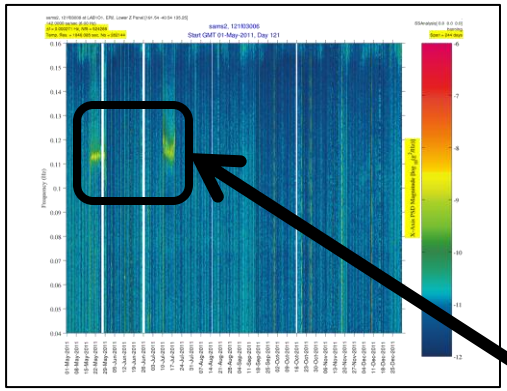
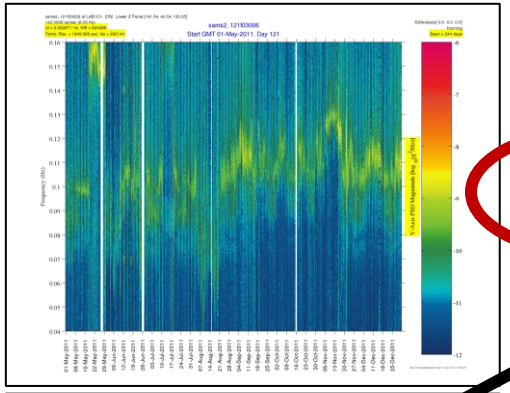
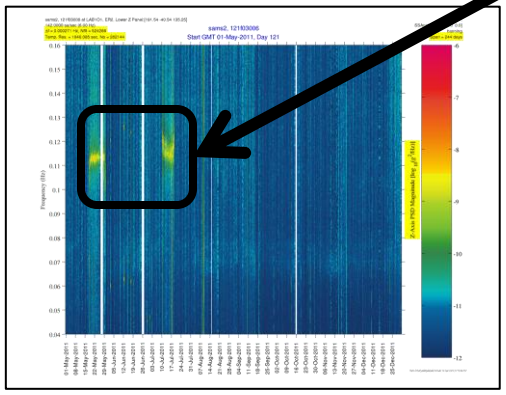
# "Mode One"



X-axis



Y-axis



Z-axis

**The small plots on this slide give x-, y-, z-axis components of same data as previous slide.**

**Predominantly Y-Axis.**

**During two separate shuttle-docked periods, we see the X- and Z-axis of the station/shuttle ensemble has a mode between about 0.11 and 0.12 Hz.**

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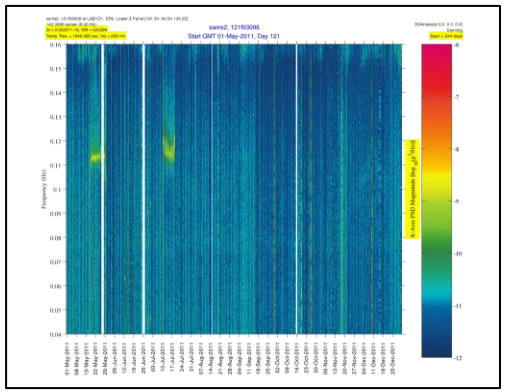
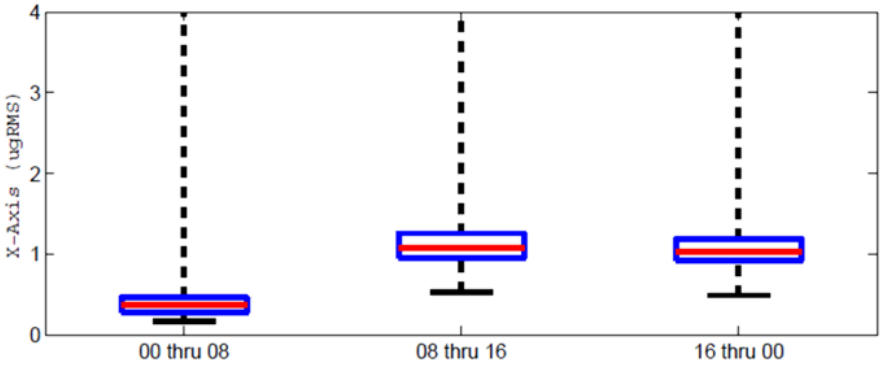
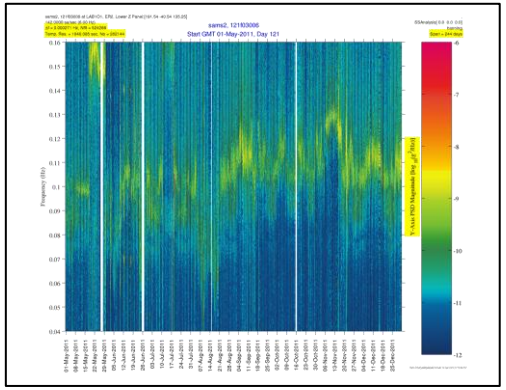
# "Mode One"

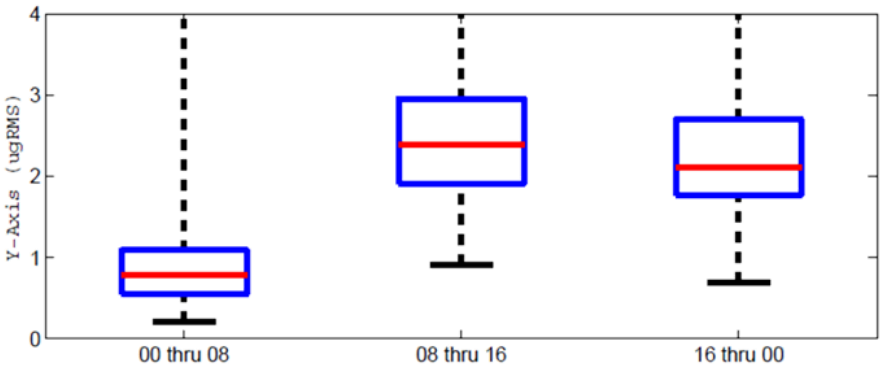


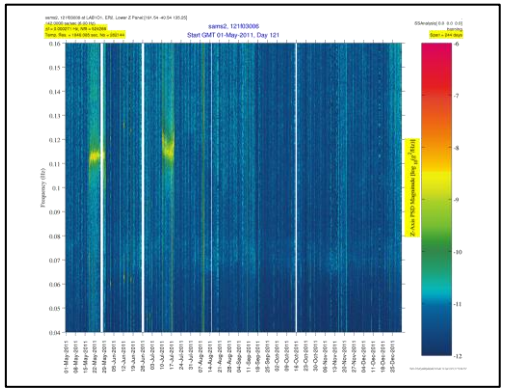
**X-axis**



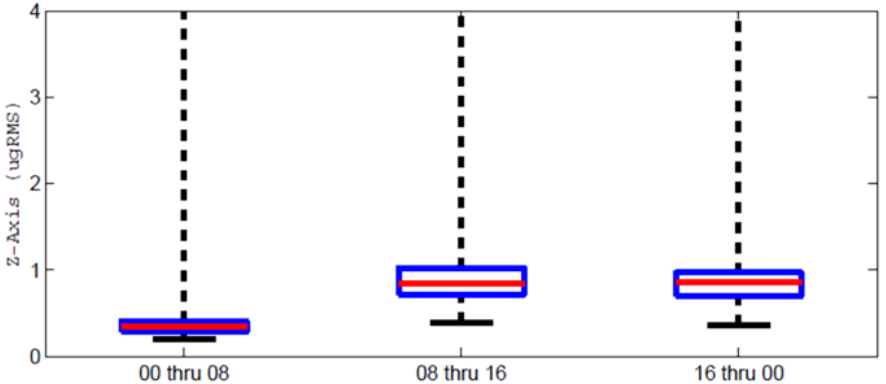



**Y-axis**

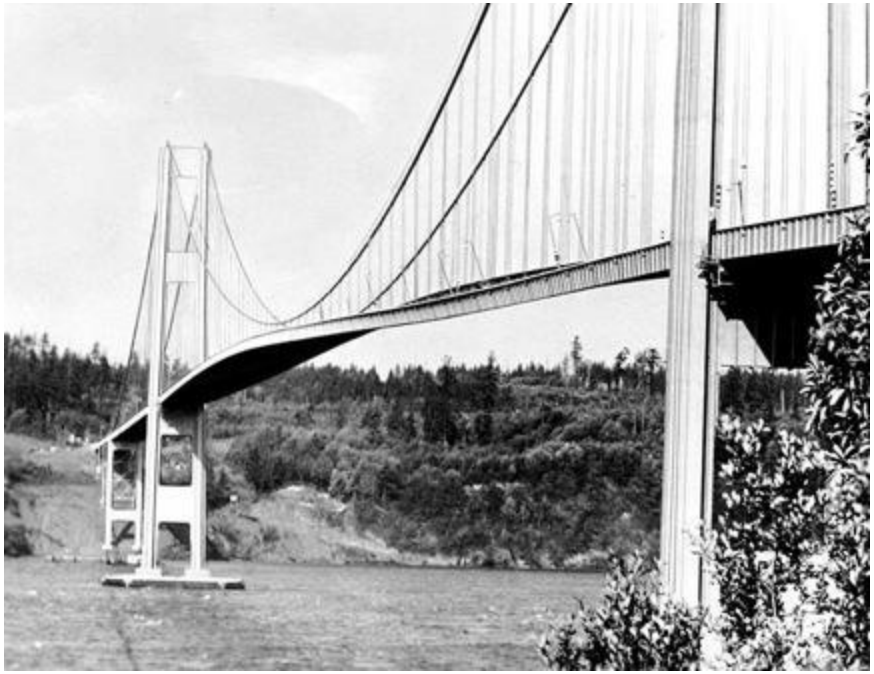


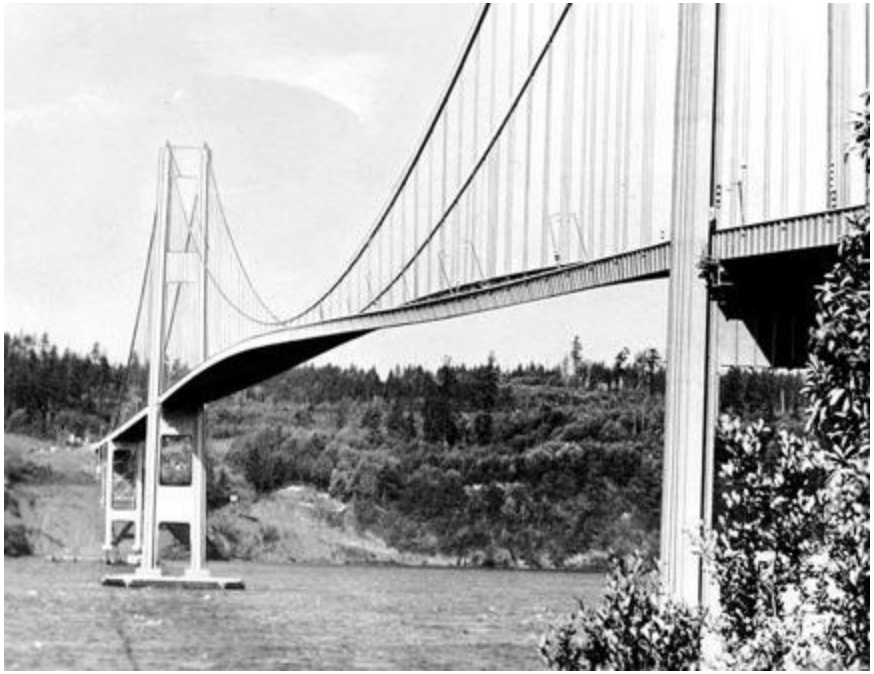
**Z-axis**



# “Mode One” Analysis



# “Mode One” Analysis



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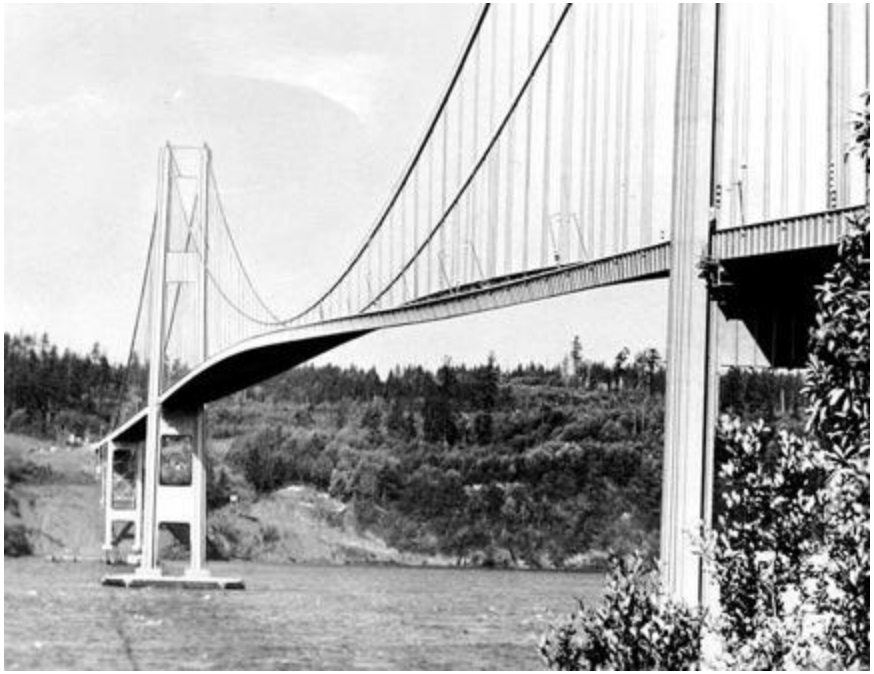
# “Mode One” Analysis

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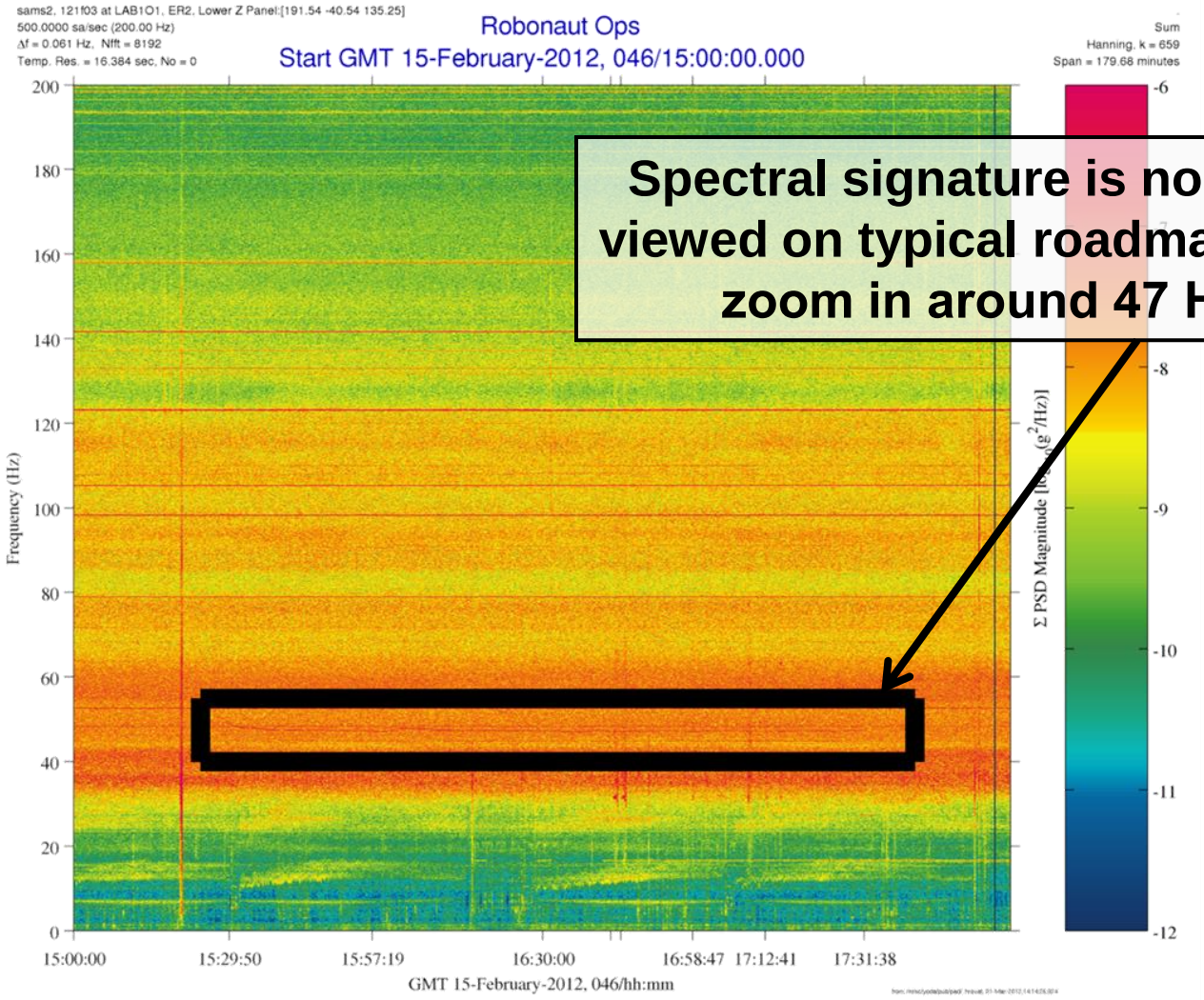
# Robonaut Ops, Qualify




**Spectral signature is non-distinctive when viewed on typical roadmap spectrogram, but zoom in around 47 Hz or so, and…**

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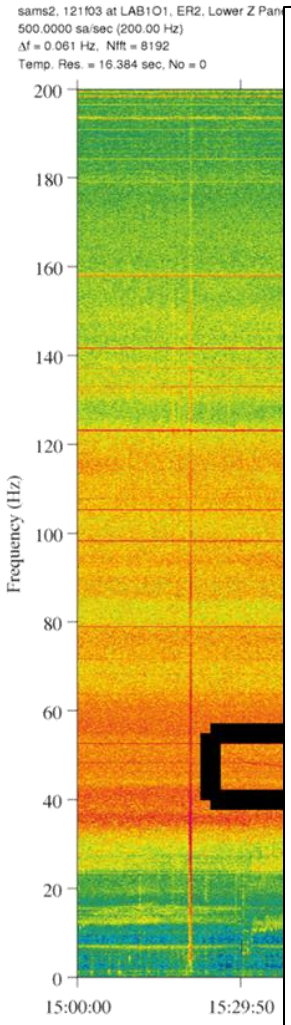
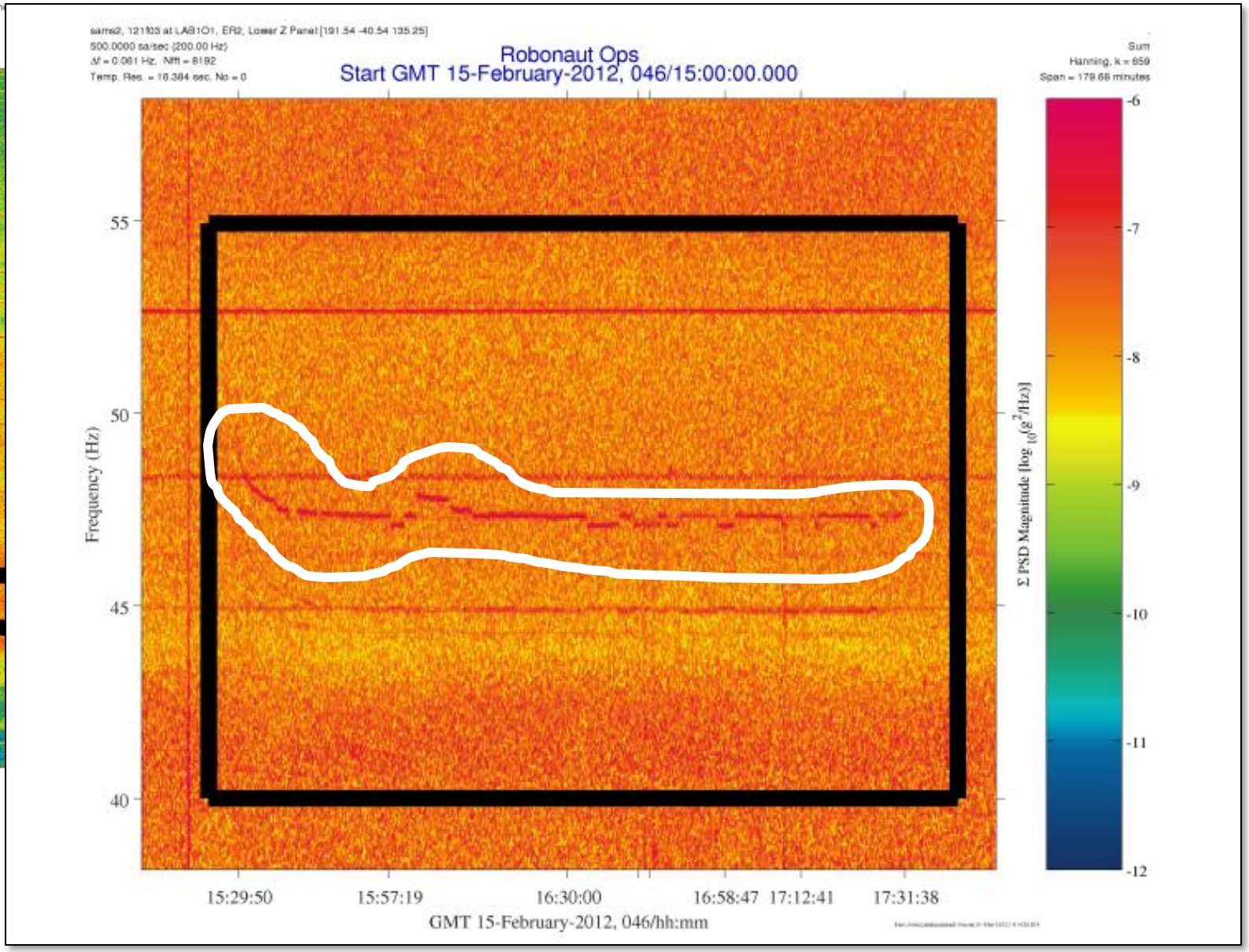
# Robonaut Ops, Qualify



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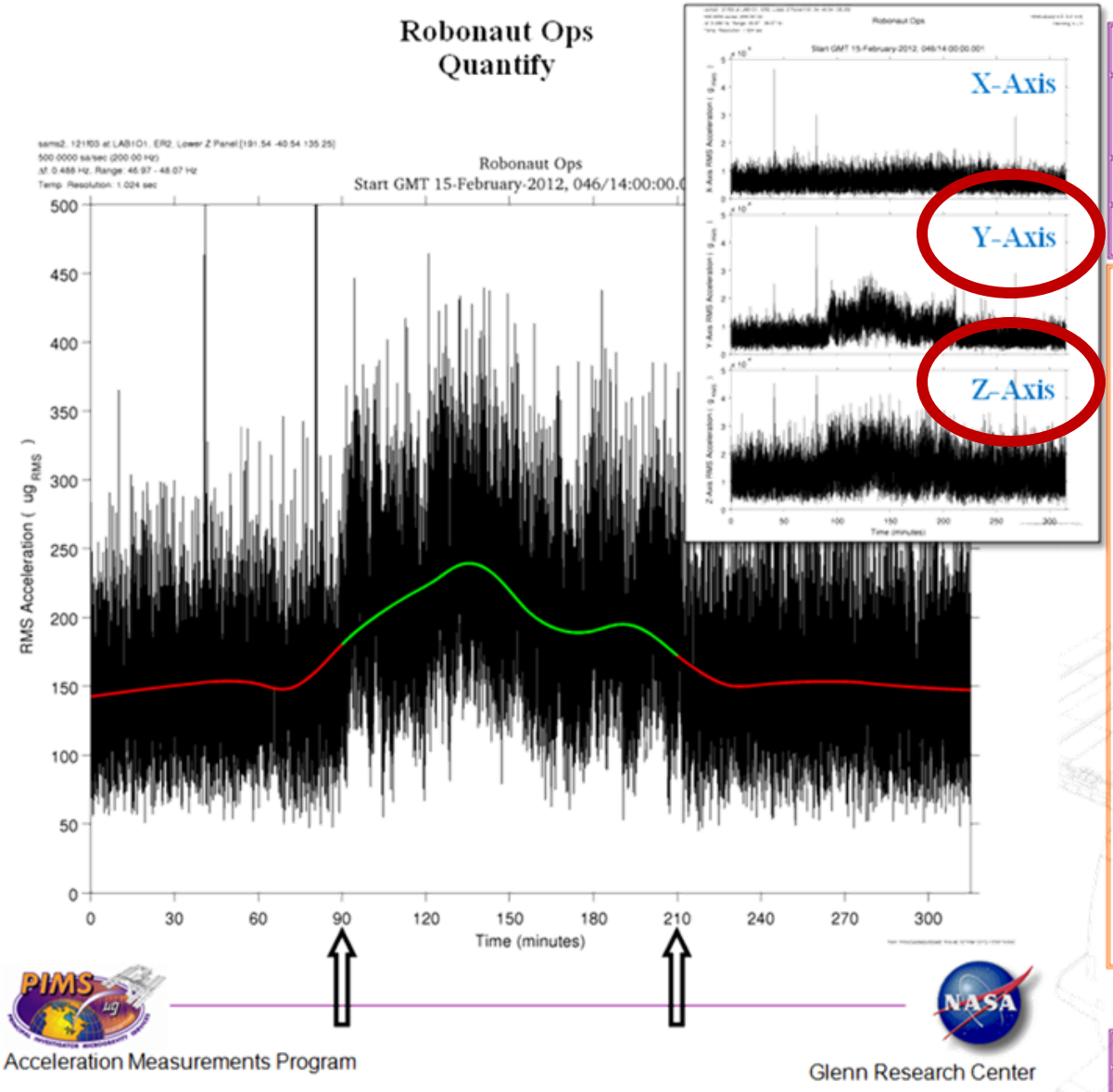
# Robonaut Ops, Quantify




PIMS ISS Acceleration Handbook

| Description | |
|---|---|
| Sensor | 121f03<br>500 sa/sec (200 Hz) |
| Location | LAB1O1, ER2, Lower Z Panel |
| Plot Type | interval RMS vs. time |

**Notes:**

- The spectral peak at ~47 Hz was the primary vibratory contributor during Robonaut Ops giving rise to the step of ~54 ugRMS above the "off" state for the frequency range from 46.97 to 48.07 Hz as shown in this table:

| Robonaut Ops | $ug_{RMS}$ |
|---|---|
| "off" (before/after) | 152 |
| "on" (during) | 206 |

- There were a couple of large transients noted during "good motion" (see the "Qualify" part of this handbook entry). The SAMS sensor registered acceleration vector magnitude transient peaks of about 11.46 mg and 9.50 mg around the time noted for those "good motion" entries, but it is not definitive that we can attribute those transients directly to the robonaut's motion.

| | |
|---|---|
| Regime | Vibratory |
| Category | Experiment Equipment |
| Source | Robonaut Ops |

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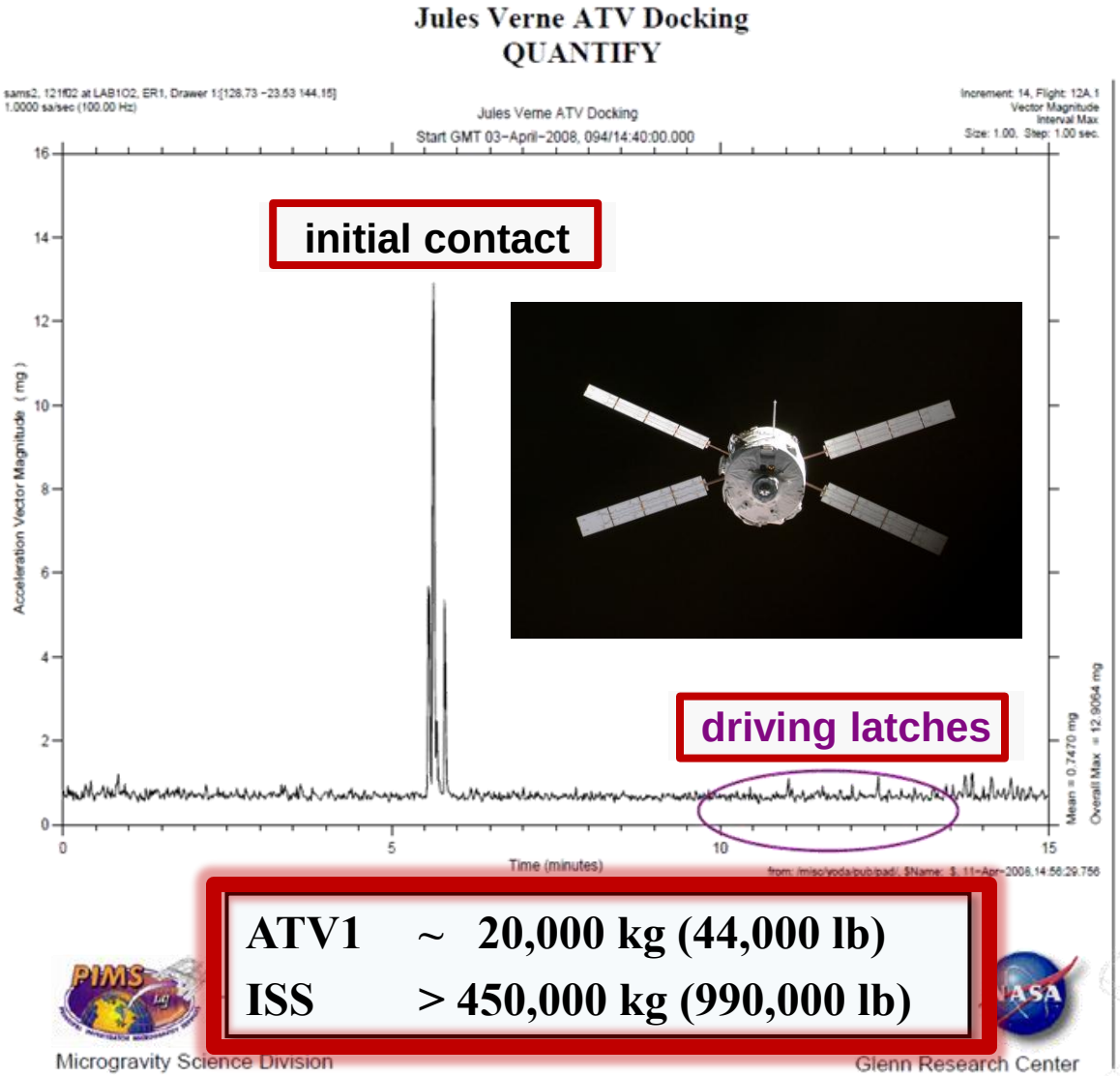
# ATV1 Docking GMT 03-Apr-2008




PIMS ISS Acceleration Handbook
Date last modified 4/18/08

| Description | |
|---|---|
| Sensor | 121f02<br>250.0 sa/sec (100.00 Hz) |
| Location | LAB1O2, ER1, Drawer 1 |
| Inc/Flight | Increment: 16, Flight: S15 |
| Plot Type | spectrogram |

NOTES:

- The ATV's initial contact with ISS occurs at approximately 6 minutes into the interval max plot.
- Peak magnitude of initial contact as measured by 121f02 was12.9 mg.
- Unlike shuttle dockings, the driving of the latches is not readily apparent in these plots. The oval calls out the time period where the driving of the latches occurred.

ATV Docking (Image from ESA Website)

| | |
|---|---|
| Regime: | Vibratory |
| Category: | Vehicle |
| Source: | ATV Docking |

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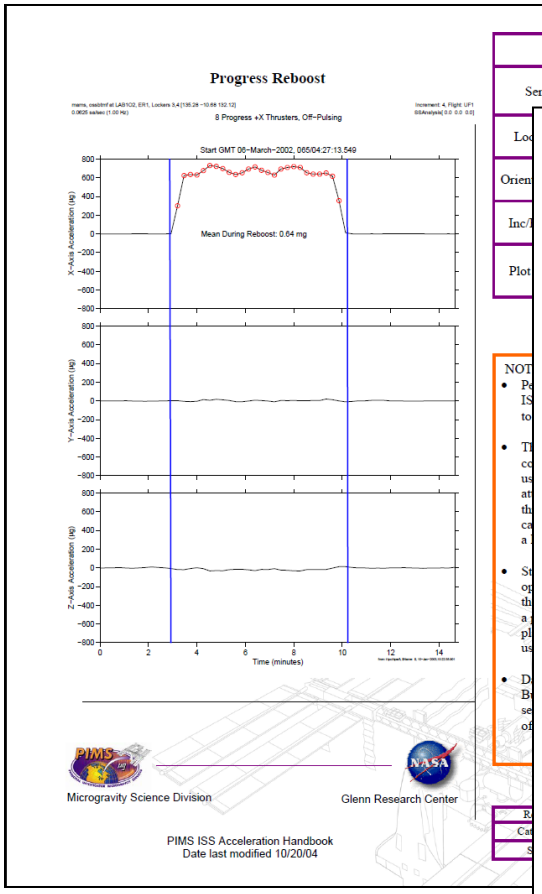
# Progress Reboosts




| Description | |
|---|---|
| Sensor | MAMS,ossbtmf 0.0625 sa/sec (0.01 Hz) |
| Loc | |
| Orien | |
| Inc/I | |
| Plot | |

**Progress Reboost**

The table below compares average acceleration from vehicle data to the average acceleration calculated from MAMS

| Reboost Information | | | | | Calculations from MAMS OSS data | | |
|---|---|---|---|---|---|---|---|
| Ignition (GMT) | Comments | Δ V (m/sec) | Duration (sec) | ΔV/T (mg) | Duration (sec) | ΔV (m/sec) | X-Axis Mean (mg) |
| 11-Oct-2001, 284/10:31 | 4 Progress +X Thrusters | 4.7 | 1560 | 0.31 | 1,629.30 | 4.63 | 0.29 |
| 11-Oct-2001, 284/15:54 | 4 Progress +X Thrusters | 4.5 | 1560 | 0.29 | 1,623.78 | 4.46 | 0.28 |
| 10-Jan-2002, 010/01:35:15 | 4 Progress +X Thrusters | 5.4 | 1877 | 0.29 | 1,863.90 | 5.3 | 0.29 |
| 10-Jan-2002, 010/03:43:26 | 4 Progress +X Thrusters | 4.8 | 1654 | 0.30 | 1,643.00 | 4.67 | 0.29 |
| 21-Feb-2002, 052/08:27 | 8 Progress +X Thrusters, Off-Pulsing | 1.35 | 239 | 0.58 | 237.40 | 1.21 | 0.52 |
| 21-Feb-2002, 052/09:59 | 8 Progress +X Thrusters, Off-Pulsing | 1.35 | 243 | 0.57 | 238.50 | 1.24 | 0.53 |
| 06-Mar-2002, 065/03:37:12 | 8 Progress +X Thrusters, Off-Pulsing | 1.0 | 158.2 | 0.65 | 157.70 | 0.93 | 0.60* |
| 06-Mar-2002, 065/04:29:07 | 8 Progress +X Thrusters, Off-Pulsing | 2.5 | 395.1 | 0.65 | 398.80 | 2.5 | 0.64* |
| 13-Mar-2002, 072/00:04:10 | 8 Progress +X Thrusters, Off-Pulsing | 2.2 | 319 | 0.70 | 300.30 | 1.8 | 0.61* |
| 13-Mar-2002, 072/00:52:49 | 8 Progress +X Thrusters, Off-Pulsing | 4.0 | 636.1 | 0.64 | 609.70 | 3.94 | 0.66* |
| 19-Apr-2002, 109/07:59 | 8 Progress +X Thrusters, Off-Pulsing | 0.73 | 118 | 0.63 | 142.70 | 0.6 | 0.43 |
| 01-Aug-2002, 213/17:24:23 | 8 Progress +X Thrusters, Off-Pulsing | 4.3 | 760 | 0.58 | 761.10 | 4.18 | 0.56 |
| 11-February-2003 042/11:34:30 | 8 Progress +X Thrusters, Off-Pulsing | 5.1 | ~1200 | 0.43 | 1168 | 4.01 | 0.35 |
| 12-March-2003 071/22:58 | Progress Manifold 1 4 Progress +X Thrusters | 1.38 | 597 | 0.24 | 634 | 1.3 | 0.21 |
| 12-March-2003 072/23:37 | Progress Manifold 2 4 Progress +X Thrusters | 0.37 | 198 | 0.19 | 219 | 0.3 | 0.14 |
| 04-April-2003 094/12:59:18 | 8 Progress +X Thrusters Off-Pulsing | 1.8 | N/A | N/A | 835 | 1.83 | 0.23 |
| 10-Apr-2003, 100/10:55 | 8 Progress +X Thrusters Off-Pulsing | 1.48 | 661 | 0.23 | 672 | 1.43 | 0.22 |

| Description | |
|---|---|
| Sensor | MAMS,ossbtmf 0.0625 sa/sec (1 Hz) |
| Location | LAB1O2, ER1, Lockers 3,4 |
| Orientation | Space Station Analysis (SSA) |
| Inc/Flight | Increments: 3-9 Flights: Various |
| Plot Type | Time Series |

**NOTES:**

- Reboost Information column contains estimates. This information was obtained from Rex Delventhal, GNC Daily Reports and/or On-Orbit Summaries.
- Values marked with an asterisk may be off by as much as 14 ug due to lack of bias compensation for OSS A-range data.

| | |
|---|---|
| Regime: | Quasi-steady |
| Category: | Vehicle |
| Source: | Progress Thrusters |

| | duration(sec) | deltaV(m/s) | xMean(mg) |
|---|---|---|---|
| MEAN | 686 | 2.36 | 0.39 |
| STD | 517 | 1.49 | 0.15 |

**statistics for 24 reboost events**

# Outline

1. Science support/customers
2. Microgravity community feedback model
3. Timeline of acceleration system deployment
4. Location of acceleration sensor deployment
5. Overview of ug environment and characterization
6. Characterize some specific events and disturbances
7. Impacts on microgravity science
8. Moving forward
9. The “best 4 hours” plot

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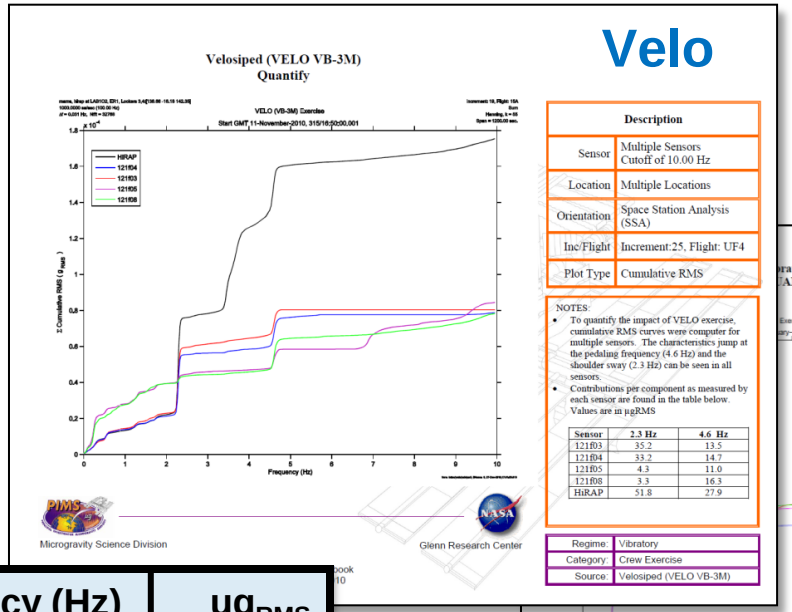
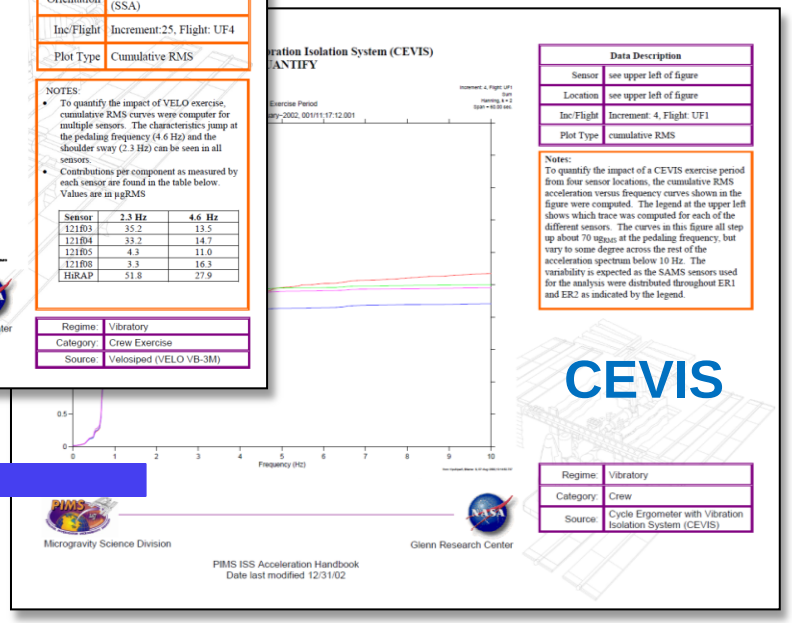
# Impacts/Crew Exercise: ISS




| Equipment | Frequency (Hz) | $ug_{RMS}$ |
|---|---|---|
| CEVIS | 2.6 | 70 |
| Velo | 4.6 | 14 |
| T2 (isolated) | <10 | 40 |
| T2 (non-isolated) | <10 | 590 |

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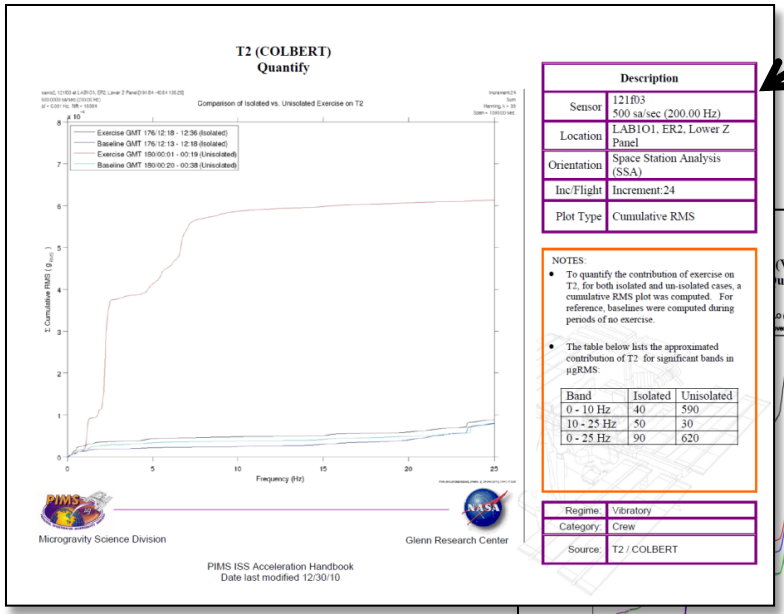
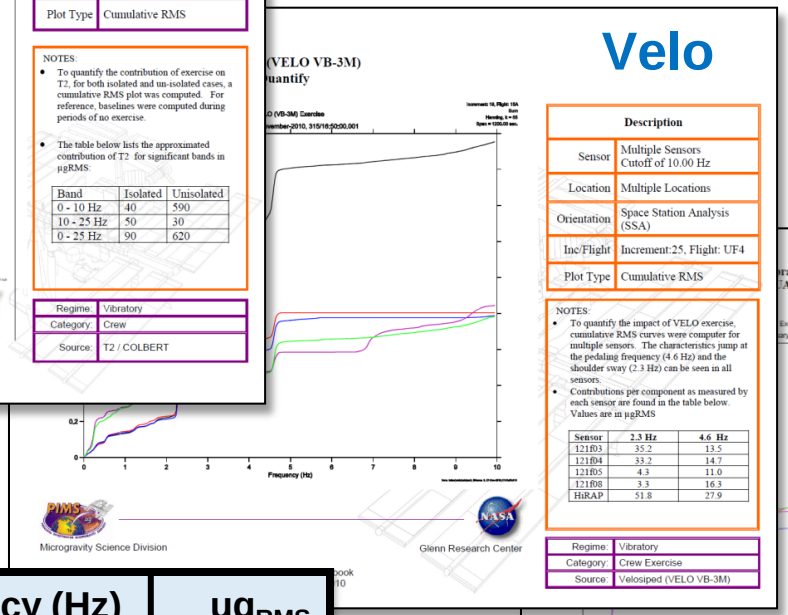
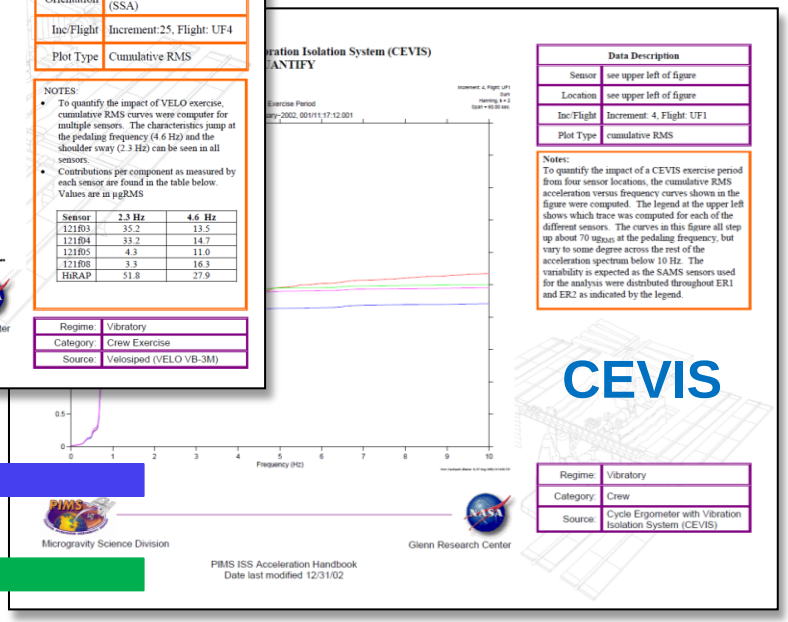
# Impacts/Crew Exercise: ISS

Treadmill 2 (**T2**)




| Equipment | Frequency (Hz) | $ug_{RMS}$ |
|---|---|---|
| CEVIS | 2.6 | 70 |
| Velo | 4.6 | 14 |
| T2 (isolated) | <10 | 40 |
| T2 (non-isolated) | <10 | 590 |

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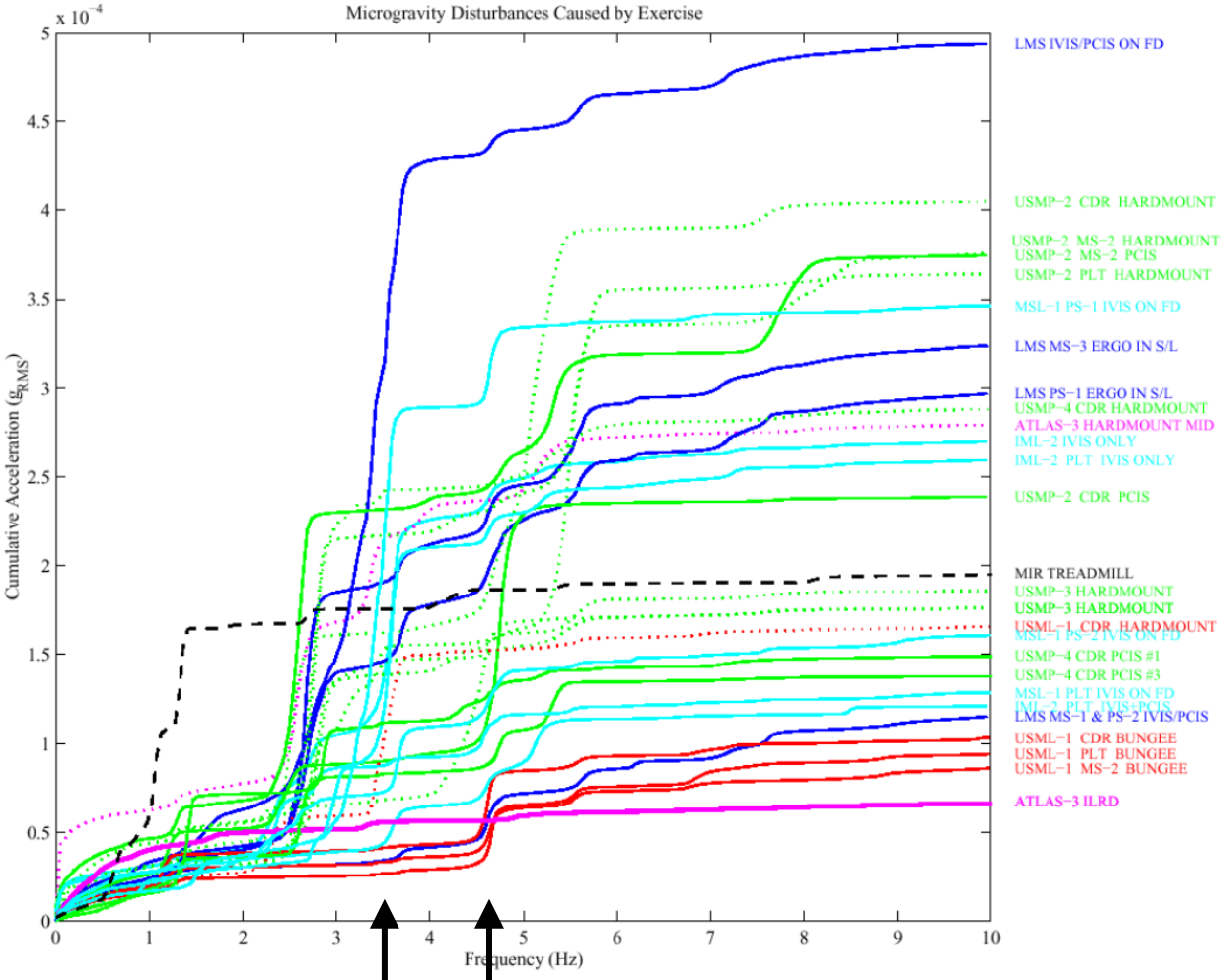
# Impacts/Crew Exercise: Shuttle




**2 spectral peaks arise from shoulder sway & pedaling rate with excitation of Shuttle structural modes @ 3.5 and 4.8 Hz**

# Moving Forward

- Ongoing microgravity acceleration services are available for principal investigators, structural studies, sustaining engineering, technology developers and the microgravity community at-large (CSA, JAXA, ESA, etc.)
- SAMS has the ability to instrument and measure in all 3 laboratories (LAB, JPM, COL) for the vibratory regime
- MAMS has the ability to measure quasi-steady acceleration and map to arbitrary locations on the ISS (rigid body assumed).

# Outline

1. Science support/customers
2. Microgravity community feedback model
3. Timeline of acceleration system deployment
4. Location of acceleration sensor deployment
5. Overview of ug environment and characterization
6. Characterize some specific events and disturbances
7. Impacts on microgravity science
8. Moving forward
9. The “best 4 hours” plot

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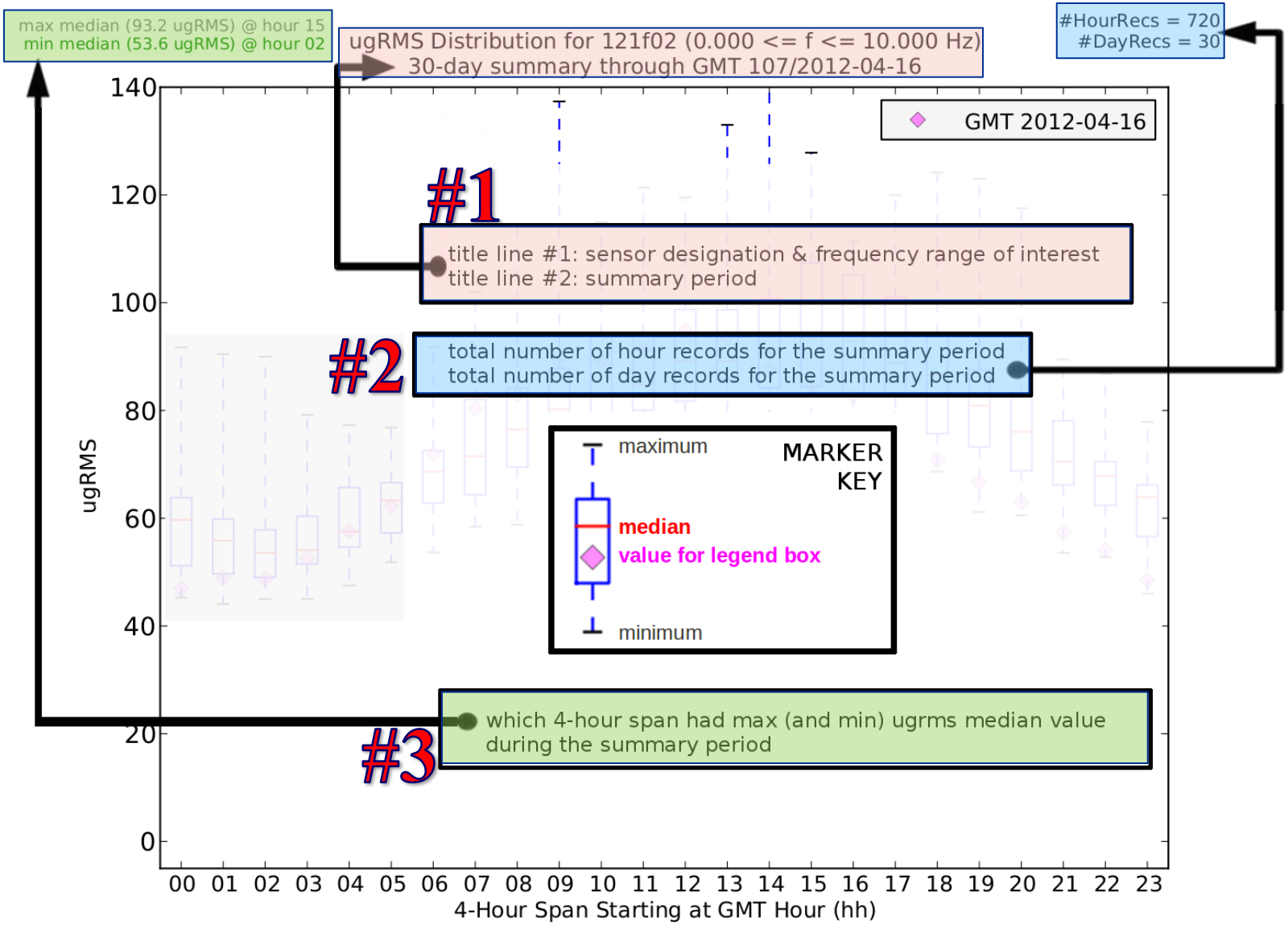
# Description for “Best 4-Hours” Plot



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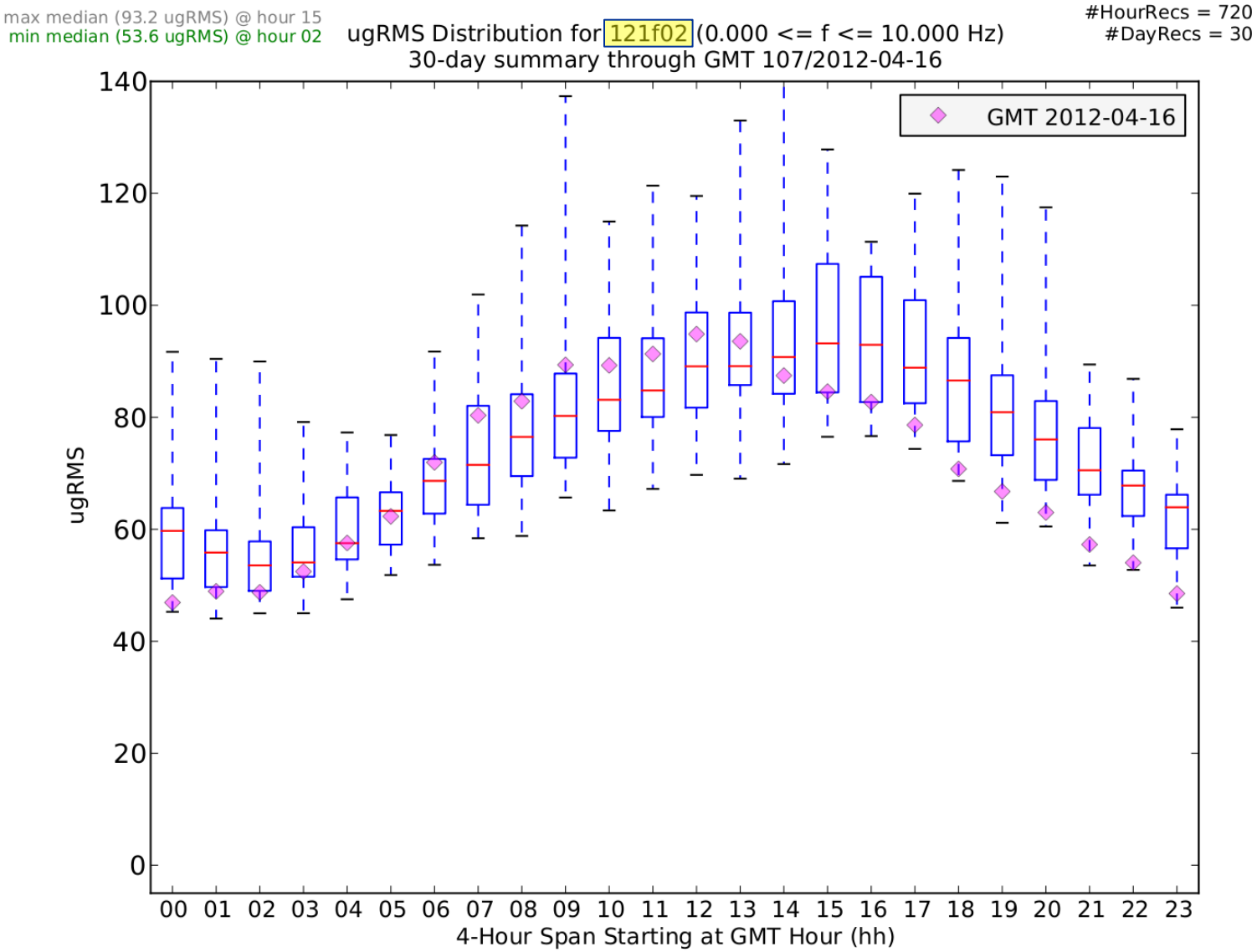
# 30-Day Summary for LAB (MSG) Location, f < 10 Hz



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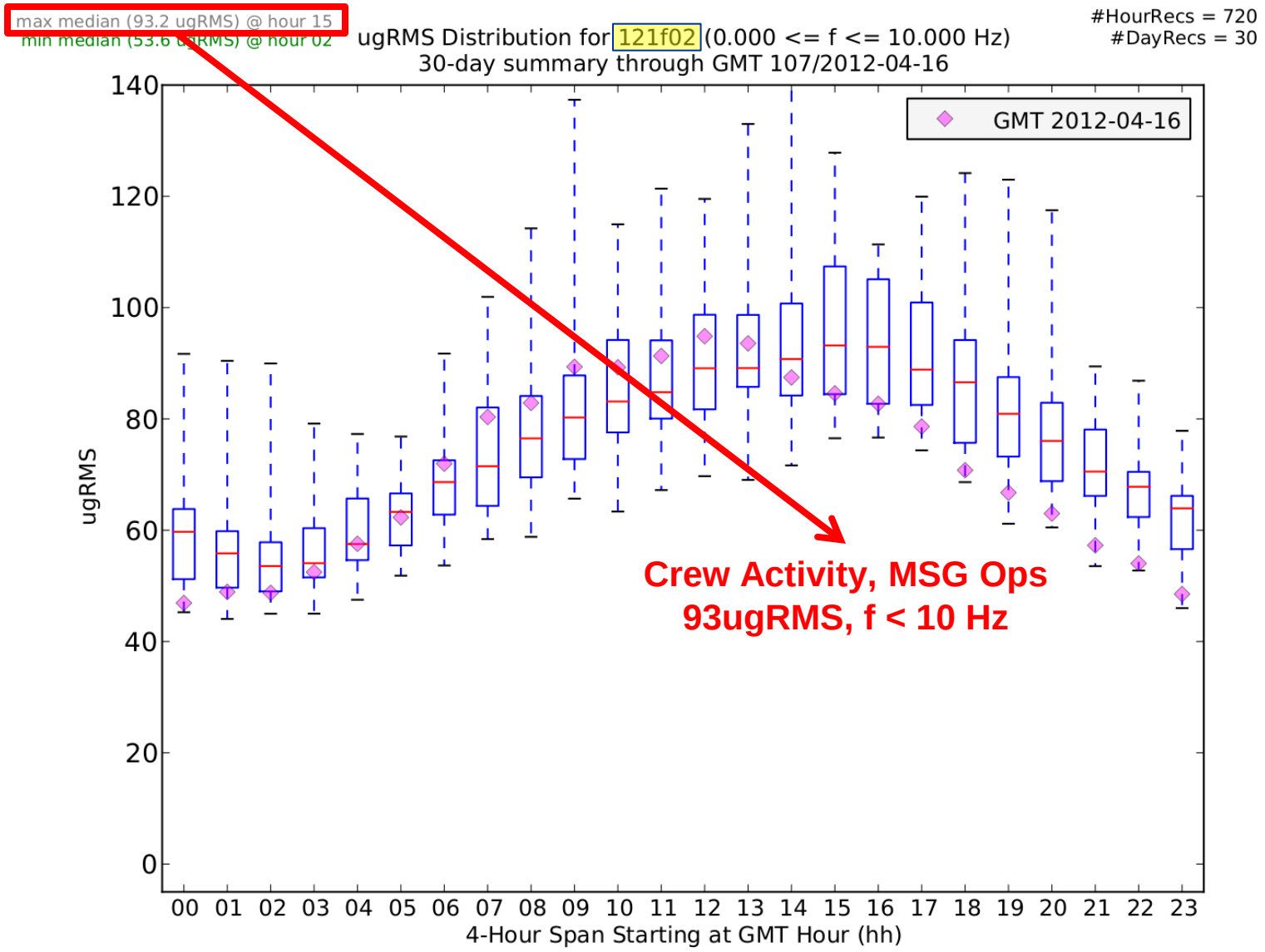
# 30-Day Summary for LAB (MSG) Location, f < 10 Hz



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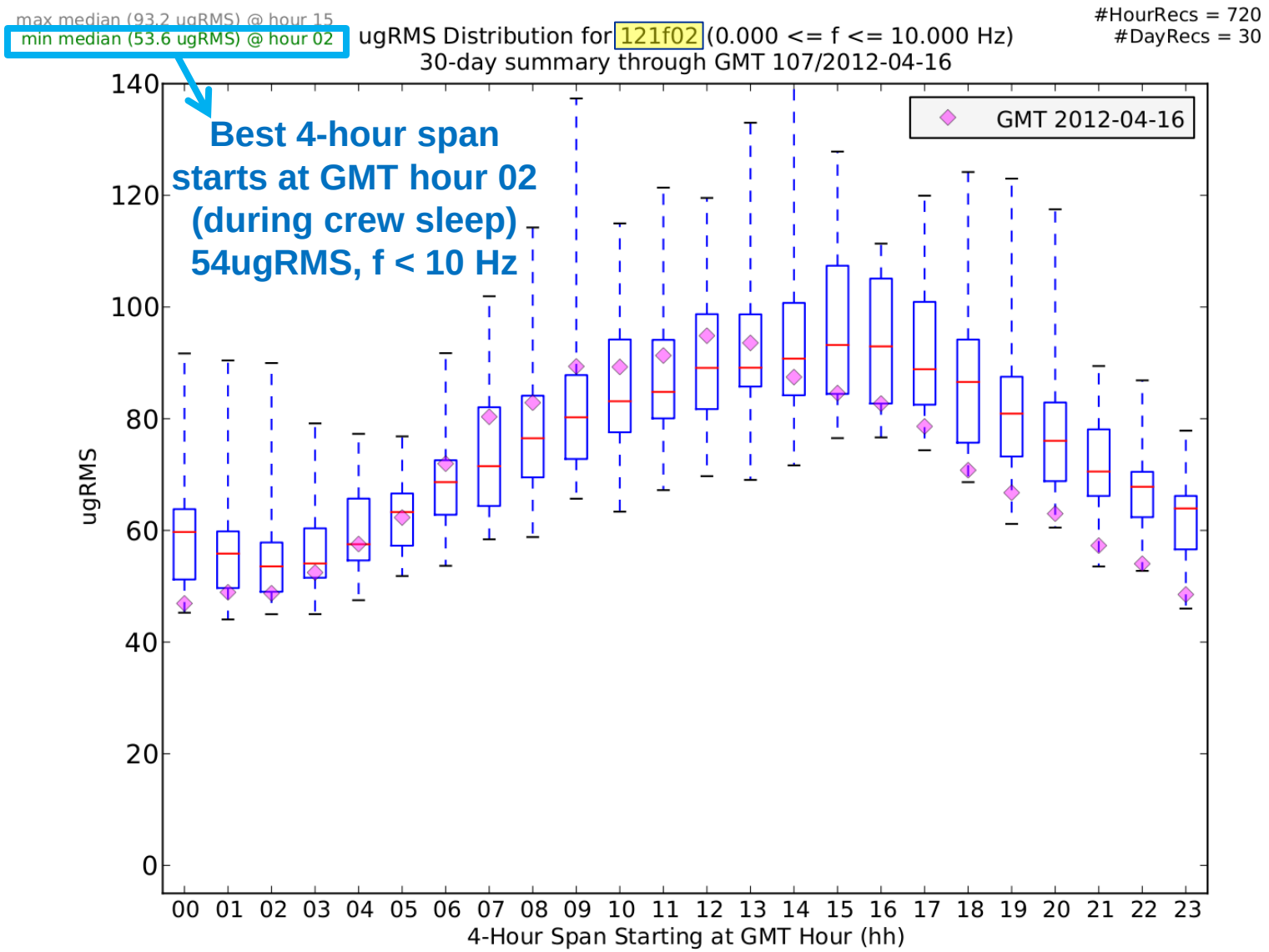
# 30-Day Summary for LAB (MSG) Location, f < 10 Hz



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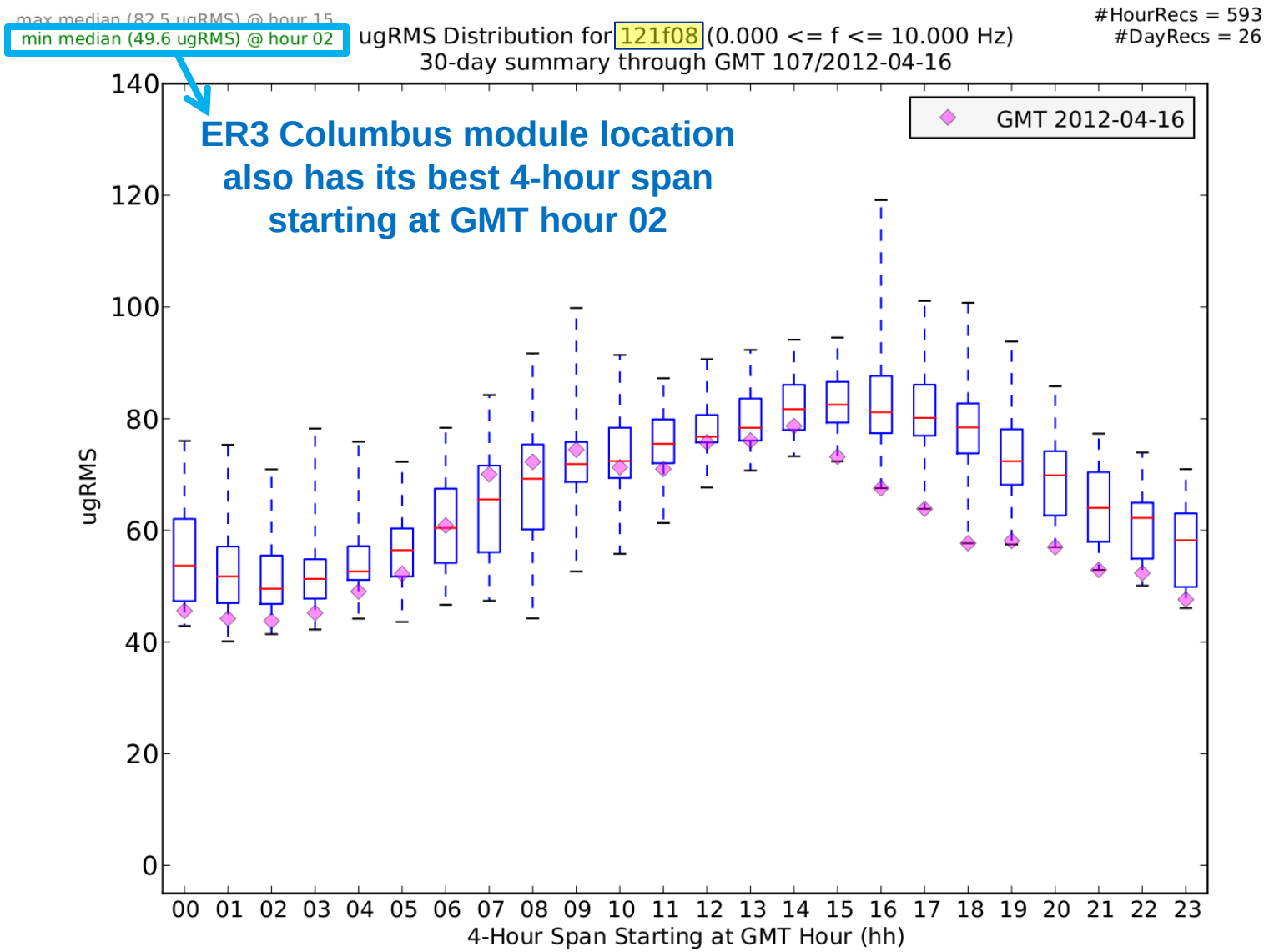
# 30-Day Summary for COL (ER3) Location, f < 10 Hz



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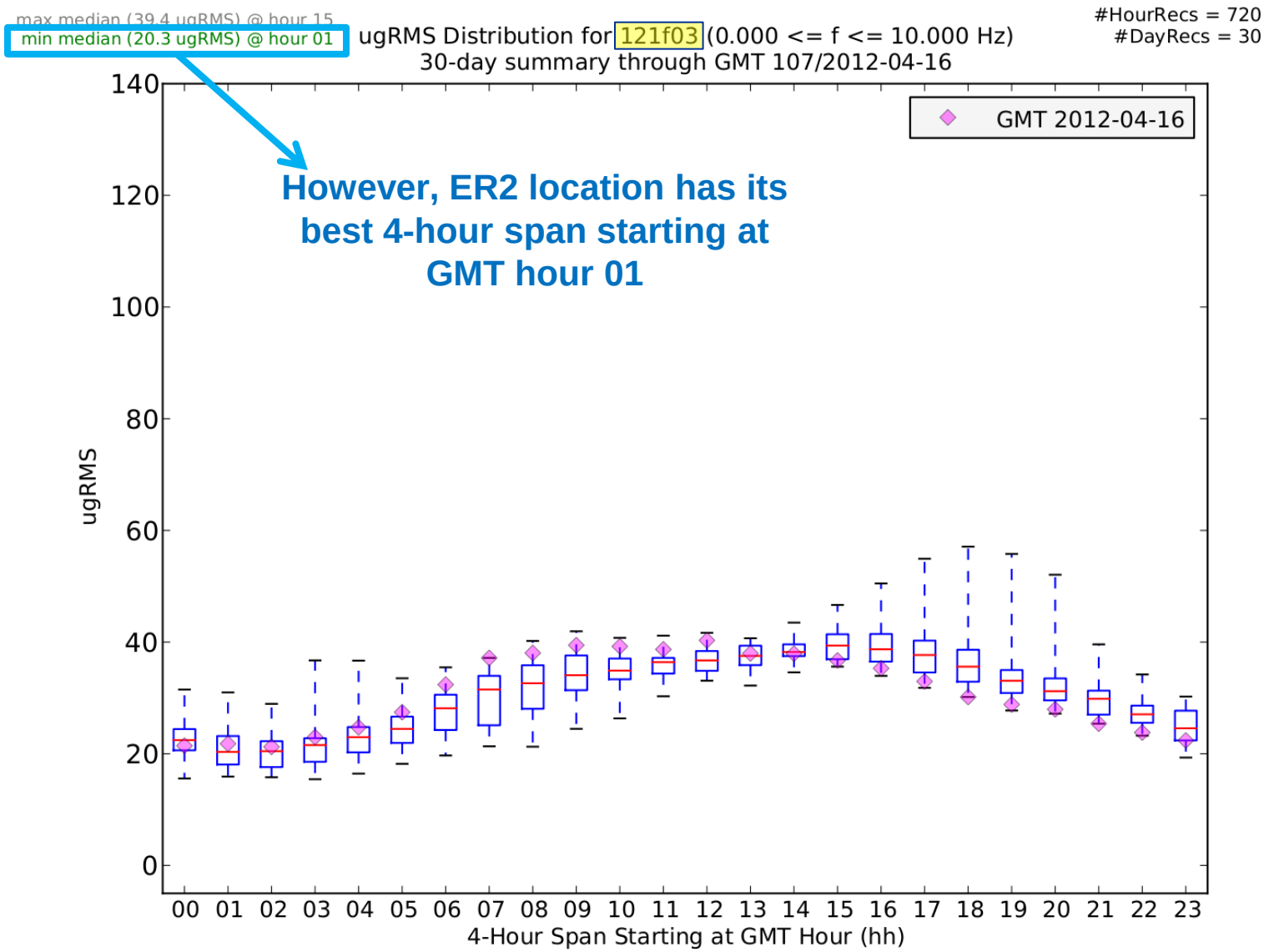
# 30-Day Summary for LAB (ER2) Location, f < 10 Hz



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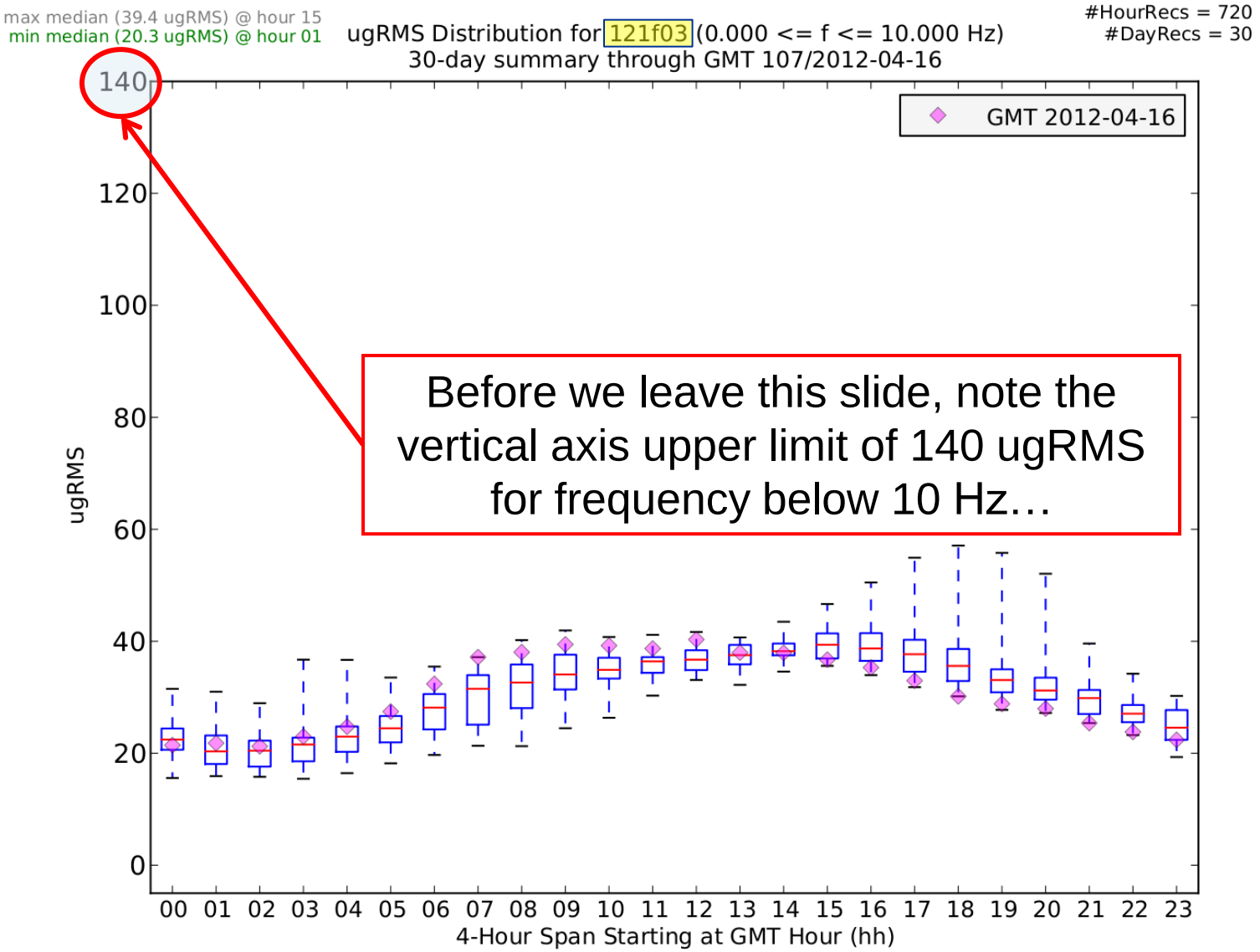
# 30-Day Summary for LAB (ER2) Location, f < 10 Hz




Before we leave this slide, note the vertical axis upper limit of 140 ugRMS for frequency below 10 Hz…

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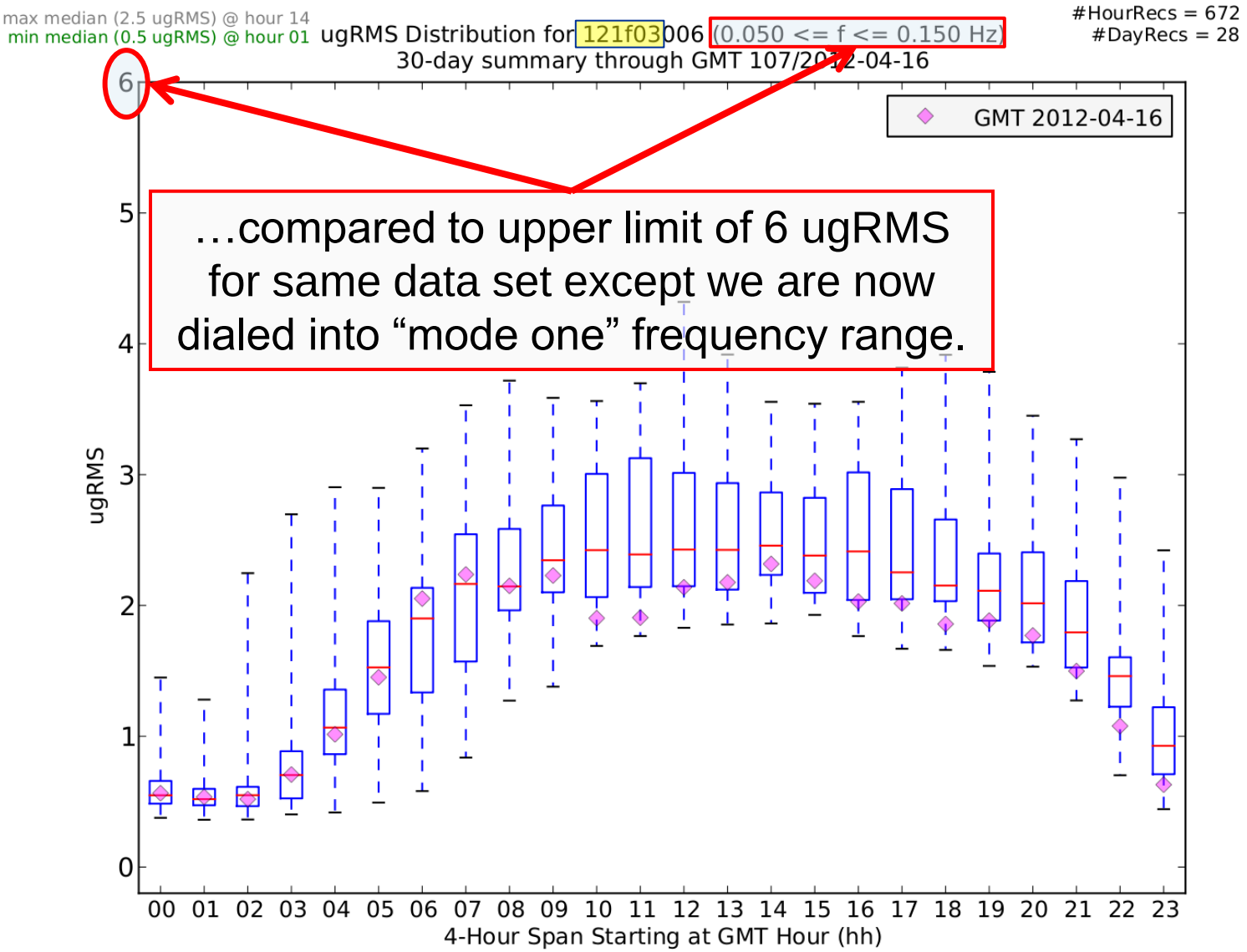
# 30-Day Summary for LAB (ER2) Location, "mode one"



# Plans to participate in…

## Open Government Initiative

TRANSPARENCY • PARTICIPATION • COLLABORATION

OPEN GOV